Eleventh Annual Report

OF THE

BOSTON WATER BOARD.

1886.

With Compliments of

BOSTON WATER BOARD.

ROCK

ELEVENTH ANNUAL REPORT

OF THE

BOSTON WATER BOARD,

FOR THE

YEAR ENDING DECEMBER 31, 1886.

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CITY OF BOSTON.

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BOSTON WATER BOARD,

FOR THE

YEAR ENDING DECEMBER 31, 1886.

Boston Water Board Office,
January 1, 1887.

The Boston Water Board presents its annual report, in accordance with the requirement of the Ordinances.

The operations of all departments have been satisfactorily conducted. The following is a concise summary of the principal expenditures of the year, with some comparisons: —

	1885.	1886.
Care and maintenance Cochituate Department	$321,137 26	$336,507 37
Care and maintenance Mystic Department	122,858 00	134,439 43
Extension of mains (paid from loans)		175,069 46
Additional supply of water (paid from loans)		144,306 04
New-High Service (paid from loans)		141,085 56

In the Cochituate Department the cost of relaying pipes, *i.e.*, replacement of insufficient sizes by larger, and of worn-out pipes by new, was $43,580.44, as against $10,784.25 in

1885. The number of feet relaid in 1886 (including the raising of the 48-inch main on Beacon street) was 12,255, as against 4,755 in 1885. Excluding this item the ordinary running expenses were less in 1886 than in 1885.

In the Mystic Department the apparent excess of expenditures is accounted for by the cost of the Shawshine surveys, pumping at the lake, and other unusual outlays.

The expenditures for extension of mains provided for the actual laying of 61,768 feet of mains, as against 54,584 in 1885; and also left a surplus of stock on hand with which to begin the work of 1887 some $20,000 larger than that on hand at the beginning of 1886.

The expenditures for additional supply include the cost of removing shallow flowage in Basin 3 and the completion of the Farm-pond conduit.

The expenditures for new High-Service include the amounts expended on Fisher-hill Reservoir, the West Roxbury Service, and some large payments for pipe.

The work of raising the Beacon-street main, above alluded to, was one of importance, requiring careful engineering and skilful mechanical treatment, and was accomplished with entire success.

For the first time a method of cleaning pipes has been put in operation sufficiently to demonstrate its practicability and usefulness. In many cases where the smaller mains have been laid so long a time as to become heavily incrusted, reducing their capacity for delivery one-half or more, it would be necessary to relay with new pipes of the same or larger size, unless cleaning could be accomplished. This would cost for 6-inch mains about $1.50 per foot, while the cleaning we have done has cost only 17 cents per foot, leaving the pipes in good condition for many years' service. The machine made use of is known as the "Sweeney" machine, and the number of feet cleaned was 15,100.

NEW CONSTRUCTIONS.

The new High-Service works are progressing as rapidly as circumstances will permit. Fisher-hill Reservoir is in a forward state; the main pipe is nearly all laid; contracts for pumps have been made with the Holly Manufacturing Co.; plans for the pumping-house are drawn, and contracts will be made for erecting that house at the earliest possible moment. The present High-Service establishment is barely adequate to the duty required of it; and, in view of the urgent demand for an extension of the service to important districts, we shall use our utmost endeavors to complete the new system

during the current year. We are able to state that the entire work contemplated in the original estimates can be completed considerably within the appropriation.

The special High-Service ordered by the City Council for the West Roxbury District is completed, and was put in use December 23. A tower around the tank on Bellevue hill remains to be erected. The expense of establishing this service cannot be fully stated, but the cost of the entire construction will not exceed the sum appropriated, $45,000.

The removal of shallow flowage from Basin No. 3 was one of the objects included in the general appropriation for additional supply made in 1883; and in that year the sum of $36,000 was expended. The work could not be resumed until 1886. Basin No. 4 having been filled during the winter, so that the contingency of a drought need not be feared, Basin 3 was emptied; plans were perfected for removing the shallow flowage to a depth of ten feet around the margin of the entire basin; contracts were made, and the work of the contractors was all completed in October. There were some sections of the basin where it was deemed desirable to prosecute the work under the direction of the Resident Engineer, by day labor, rather than by contract. This work was continued until inclement weather prevented further progress, and was so far completed that the basin could be put into service. There only remains to be done a few days work in riprapping a small section, which can be finished at convenience, when the water has fallen sufficiently during the coming summer. The whole work (including that done in 1883) will cost about $132,000. It has been done in the most thorough manner, and we have great confidence that the results in the way of the improvement of the water in this basin will amply justify the outlay.

The Farm-pond conduit was completed in June, and has been in use a part of the season. It has been found, however, that in the present condition of the pond the water takes no harm from passing through it, but is rather improved than otherwise; so that, at present, the use of the conduit is not required. Should unfavorable conditions, such as have in former years pertained to the pond, again arise, the conduit will doubtless prove serviceable.

WATER-RATES.

Notwithstanding the reduction of water-rates made for 1886, a considerable surplus of revenue accrued to the Sinking-Fund. We have, therefore, carefully considered the matter of making a further reduction for the year 1887, and

find ourselves able, in adopting a new scale of rates, to reform, as we think, the method of making the dwelling-house assessments. Hitherto the tax has been based upon a valuation of the real estate, including the land. This plan, though administered discreetly with a view of avoiding inequality of assessments, was still liable to produce such inequality; and we have ordered the valuation to be taken of buildings only. The general effect of this new scale will be to make the average of dwelling-house rates about ten per cent. less than the old rates. The operation of the scale of meter-rates adopted last year was found to give takers by meter a larger proportionate reduction than to others, amounting to more than ten per cent. on the average. Therefore, meter-rates cannot be further reduced, but will stand as established for 1886.

There is no probability that rates can be further reduced at present. There will be a natural increase of consumption and revenue, but the yearly outlays for extension and additional supply will create additional charges which can hardly be much exceeded by the increase of income.

QUALITY OF THE WATER.

The quality of the water of our main supply has been good throughout the year. It not only has shown by analysis a very uniform condition of chemical composition, but it has been free from any taste or color suggesting temporary deterioration. It has sometimes happened, and may happen again, that the color or taste is affected, while the healthfulness of the water is not.

We frequently find in the published reports of water commissions of other cities tables of comparison of the quality of the water furnished in various places, and in these tables Boston generally appears pretty near the foot of the list. We do not suppose anybody has intended misrepresentation, but the information is customarily quite ancient, and the rating of Boston on analysis of water taken from some brook specially liable to foulness is certainly a distortion of facts. We have thought it well to secure reliable information by independent inquiry, and are glad to be able to assure our citizens that our water, as tested by the best known methods of comparison, is good. The following is a statement of the results of analyses recently made: —

	Free Ammonia.	Albuminoid Ammonia.	Chlorine.	Residue.			Hardness.
				Fixed.	Volatile.	Total.	
Boston (main supply)	0.0000	0.0230	0.60	1.50	3.60	5.10	1
" (Mystic ")	0.0628	0.0320	2.45	8.45	5.05	13.50	6
New York	0.0020	0.0220	0.55	4.40	5.00	9.40	3½
Buffalo	0.0000	0.0126	0.40	8.50	6.00	14.50	2
Lowell	0.0294	0.0138	0.30	5.60	3.10	8.70	. .
Providence	0.0334	0.0264	0.45	4.90	13.90	18.80	2
Newton	0.0002	0.0062	0.60	2.80	3.40	6.20	2
Shawshine River	0.0004	0.0144	0.60	3.40	1.20	4.60	1¼

(Figures express parts in 100,000. The Lowell water was taken from a filtering gallery; that of the other cities named was taken from the house-service. The Mystic result is obtained by an average of two analysis, taken nearly simultaneously.)

To the uninstructed reader it may be explained that, in a general way, the purity of water is rated according to the paucity of the elements enumerated in the above table; yet there is no common standard by which to judge all waters, on account of the varying conditions which affect their quality or the water-sheds where they are collected.[1] While this is

[1] [Note supplied by Prof. E. S. Wood, Harvard Med. Coll.] The inferences to be drawn from the amounts of free and albuminoid ammonia, chlorine, residue, etc., in a specimen of water, vary very much according to the source of the water, as, for instance, whether it is a surface-water from a shallow well, or an artesian well, whether the gathering ground is gravel or limestone, etc., etc. Surface-waters differ also according to the nature of the sub-soil through which the water flows; a notable instance of this is the difference between Fresh-pond water, which supplies Cambridge, and the surface-waters supplying neighboring cities and towns. The water of Fresh pond comes from the surrounding high land, which is of the same general character, as regards soil, etc., as the gathering-ground of Cochituate, or other sources of water supply in this vicinity; but the water of Fresh pond, before reaching the pond, searches through old sea-beds, which contain a large amount of lime and magnesian salts, so that the water of Fresh pond is 6 or 8 degrees hard, while that of Cochituate and other surface-waters in this vicinity are only one or two degrees hard. So that no definite rule can be laid down in regard to the amounts of the different ingredients which should lead to the acceptance or rejection of a specimen of water.

In this region a very pure surface-water, after proper storage and aeration, should not contain *habitually* more than 0.0080 of free ammonia 0.0150 of albuminoid ammonia, and 1.0 or 2.0 of chlorine per 100,000 of water. A surface-water the gathering-ground of which is *very* near the sea-coast, may have a considerably larger amount of chlorine, on account of the salt in the vapor coming directly from the sea. A large excess of both free ammonia and chlorine together usually means sewage contamination, in which case the albuminoid ammonia is also usually largely increased. If the ammonias are alone increased, the chlorine being the same as in the pure waters of that region, the contamination is probably due to vegetable matter only. In ponds or large basins we usually expect to find more vegetable decomposition products in the fall after the surface of the pond begins to get decidedly cooled, because the cooling of the water at the surface makes the surface-water fall, and the warmer water at the bottom, which naturally contains more vegetable decomposition products, rise. This, you may notice, has almost invariably been the case with the ponds and basins of the Boston water-supply in October.

No inferences can be drawn from the amount of residue and hardness, unless we know the amount which is natural in waters in the same district and of the same nature (*i.e.*, whether surface, subsoil, or artesian).

true, it is also true that a definite standard may be adopted for any particular class of waters collected under about the same conditions. It is thus possible to compare the analysis made under the same conditions from year to year and to form a correct conclusion as to whether the water is, in a general way, improving as a source of domestic supply or whether it is deteriorating.

In 1883 a systematic periodical examination of the waters was begun, and has been since continued, so that we have at hand a means of observing, from time to time, the changes which appear in the several chemical constituents of the waters.

The Board believes that it is fully warranted in the following conclusions: —

1st. That the Mystic water, originally good, is gradually deteriorating.

2d. That the Cochituate water is a very pure source of supply, and that its quality has not materially changed since its introduction.

3d. That the Sudbury water is of excellent quality, and is improved in its passage through the storage-basins, both as to color and condition, and that the changes already made at great expense, and others which are in contemplation, will have a still further influence of a beneficial character.

Any good water, however, is subject to some insidious and abnormal growth of vegetation at any time, which will seriously impair its quality, for the time being. It is only by having a large reserve in the way of storage-basins and by the exercise of vigilance that a common standard of purity can be maintained; and even then the patience of water-takers may be sometimes called upon to tide over some temporary difficulty.

For the purpose of comparison we have placed in the foregoing list the water of Newton, because it is reported to be, and is, very good. It is taken from filtering-galleries alongside the Charles river, and is said to be water intercepted on its way to the river, and not the water of the river itself. The other extreme is to be found in the water of Providence, which is taken from a river supply, with little opportunity for purification before delivery to the service. The Buffalo analysis indicates, as might be expected from the enormous body of water furnishing the supply (Lake Erie), a good degree of purity, though showing much solid matter. The best comparison for us is with New York, the supply for that city being taken and treated in much the same manner as our main supply, though on a scale much larger, and offering good opportunities for

securing original cleanliness and purity. It is well known that Philadelphia, Washington, and many of the large cities, use water inferior to that supplied to New York and Boston. As to the Mystic water the analysis offers opportunity for suggestive comparisons, and our remarks in another place indicate the reasons why this water cannot be expected to improve, but rather to deteriorate.

In view of the importance of the matter of possible communication of disease by means of impure river waters, the Board used the occasion of a visit to Philadelphia to make inquiries respecting the prevalence there of typhoid, said to be traceable to the use of Delaware river-water. To assist in their investigation Dr. J. H. McCollum, City Physician of Boston, was invited to accompany them. He has made a report to us, covering the ground so thoroughly that we print it in full as an appendix to this report. The most interesting fact developed is the great danger to public health from the use of well-water obtained in a closely populated district, and inferentially the dangers to river-water when a dense population lies near it. Incidentally it is also interesting to note the remarks upon the comparative freedom from typhoid which Boston has enjoyed since the introduction of Cochituate water.

THE REMOVAL OF POLLUTIONS.

We are unable to report the definite adoption of any plans for local systems of sewerage in the neighborhood of our sources, but the subject has been discussed and investigated by local authorities to a greater extent than ever before. This is particularly true of the towns of Framingham and Marlboro'. In the latter town both the Board of Selectmen and the special town committee have met us in a very fair spirit, and we hope to bring negotiations to an early conclusion. In Framingham the problem is more difficult, and the town authorities are quite justified in seeking the fullest knowledge of details of different schemes proposed, to determine their merit, both on the points of effectiveness and cost. We have undertaken to assist them by means of new investigations by our engineers, in acquiring all possible information. The town-meetings lately held show a lively interest in the matter; and when, as we hope may be the case at an early day, some plan can be demonstrated to the satisfaction of the intelligent and public-spirited authorities of this town to be the best, we anticipate no serious difficulty in arriving at a fair arrangement.

With respect to individual cases of direct pollution we have exercised all possible diligence, and they have been almost wholly obliterated. Those which remain are mostly remote from the reservoirs. We have, during the year, invoked the law, in several cases, successfully, notably in a few obscure cases on Pegan brook, with a result very gratifying, so far as the appearance of that stream goes.

In this connection we note that the portion of Lake Cochituate lying between the outlet of Beaver Dam brook and the lake proper is susceptible of decided improvement. When the lake is drawn down in summer, the water in the section alluded to, from its shallowness and sluggishness, and from its deterioration by the waters of Beaver Dam and Course brooks, is of a character likely to injure the waters of the lake. We have in contemplation a scheme of improvement which will be presented to the City Council as soon as practicable.

CONSUMPTION OF WATER.

It would appear, by the tables of consumption, that the rate of use per capita has been slightly increased during the year. Previous to the year 1883 the average rate of consumption was over 90 gallons per capita per day. In that year the systems of Waste Detection, by the use of the Deacon meter and of house-to-house inspection, were established, and the result of six months' work indicated the discovery and correction of such a number of leaks in mains, and of defective house-fixtures, as to reduce the average consumption per capita to a little over 70 gallons per day. The continuance of the detection and inspection, in 1884 and 1885, resulted in no further reduction of the average consumption, but operated to prevent the increase of wasteful causes, and to keep the average consumption about the same. And while the past year shows a small apparent increase, we are satisfied that there has been no real augmentation of waste in the strictly domestic service, and whatever increase is shown arises from the growth of the city in business prosperity, creating demands for the use of water not chargeable to "population" as such.

The question as to what is a legitimate supply for a city like Boston has created much discussion, and brought out widely varying views. Especially when the city appears before the Legislature as an applicant for additional water-rights, it is quite customary to quote, as conclusive, examples of cities, American and English, which use less water. Without pretending to have exhausted the subject we deem

it timely to mention a few considerations which seem to us to show that our consumption is not only not wasteful, but is quite economical. It must be apparent that in instituting comparisons there must be some correspondence in the circumstances of the cities compared. In the first place, we may well reject all comparisons with foreign examples. If, as a whole, they bear against the average results in the United States, it would simply indicate that there are characteristic national or local causes for the difference. As a matter of fact there are strong foreign examples to indicate that large cities, with thrifty commercial interests and population, use quantities of water corresponding to those consumed by us; but we may better consider our own country, with its multitude of large communities, about which we have some knowledge, and from whose surrounding circumstances we can draw reasonable deductions.

The latest reported returns of consumption in the larger cities, with some from cities of a smaller size, are given in the accompanying table. [See page 10.]

We find, at the outset, that but one city in the United States, of equal size, uses less water than the city of Boston. That fact alone may not be conclusive; for it may be that, in some localities, the source of supply is so abundant that there is no occasion for economy; yet it will be found that in these localities there is no known cause of deliberate or excessive waste.

We find further that the experience of the smaller cities is, that as the population increases, the consumption per capita is augmented.

Mr. J. T. Fanning, C.E., whose work on "Water Supply for Cities" shows much research, and is regarded as the best American authority, epitomizes the requirements of American cities as follows: —

a. For ordinary domestic use, not including hose use, twenty gallons per capita per day.

b. For private stables, including carriage washing, when reckoned on the basis of inhabitants, three gallons per capita per day.

c. For commercial and manufacturing purposes, five to fifteen gallons per capita per day.

d. For fountains — drinking and ornamental — three to ten gallons per capita per day.

e. For fire purposes, one to ten gallons per capita per day.

f. For private hose, sprinkling streets and yards, ten gallons per capita per day, during the four driest months of the year.

g. Waste, to prevent freezing of water in service pipes and house fixtures in Northern cities, ten gallons per capita per day, during the three coldest months of the year.

h. Waste by leakage of fixtures and pipes, and use for flushing purposes, from five gallons per capita per day, upward.

Finally, Mr. Fanning gives the following as the approxi-

CITY.	Year of Returns.	Population.	Daily average consumption. — *Gallons.*	Gallons per Day per Inhabitant.	Number of Taps.	Gallons per Tap.	Number of Meters or Motors in use.	Miles of pipe.	Percentage of total consumption used through Meters.
New York	1886	1,400,000	107,000,000	76.4	96,000	1,115	15,000	604.0	23.4
Philadelphia	1886	975,000	78,433,289	80.4	165,000	475	284	....	3.8
Brooklyn	1886	750,000	45,322,100	60.5	75,425	601	2,237	....	1.7
Chicago	1885	760,000	91,647,600	120.6	98,688	928	3,374	565.2	13.6
Boston	1886	460,000	34,027,700	74.0	69,510	489	4,232	547.4	22 0
St. Louis	1886	410,000	30,000,000	73.2	32,000	938	2,143	....	12 2
Baltimore	1886	400,000	30,000,000	75.0	55,000	545	927	227.4	23.9
Cincinnati	1885	310,000	19,800,400	64.0	28,522	694	1,686	....	....
Buffalo	1885	250,000	28,606,560	114.4	22,735	1,258	125	191.0	15.9
Cleveland	1885	192,000	17,950,694	93.5	18,411	975	1,175	212.3	18.9
Washington	1886	175,000	27,000,000	154.3	21,122	1,278	4	....	....
Milwaukee	1886	165,000	17,878,436	108.3	13,243	1,350	872	120.6	15.2
Louisville	1885	159,000	9,920,340	62.4	9,709	1,022	509	127.14	....
Newark	1885	153,000	11,784,160	77.0	16,908	697	391	....	....
Providence	1886	120,000	4,822,125	40.2	12,552	384	7,135	190.0	....
Rochester	1885	110,000	6,343,292	57.0	15,810	401	978	165.4	11.5
Indianapolis	1886	100,000	5,000,000	50.0	1,701	2,939	134	....	12.0
Albany	1885	95,000	8,671,508	91.3	13,906	624	59	82.4	....
Allegheny	1886	90,000	14,132,000	157.0	14,728	959	0	....	....
New Haven	....	75,000	8,000,000	106.7	...	....	42	....	5.0
Richmond	1885	70,000	9,906,122	141.2	....	....	31	57.87	....
Lowell	1885	64,050	3,561,000	55.0	6,913	515	1,421	79.25	41.1
Worcester	1885	69,000	3,450,000	50.0	7,191	480	6,103	97.9	39.4

mate estimate of the average daily consumption, basing his calculations entirely upon the population : —

Places of	10,000	population,	35 to	45	gallons	per capita.
"	20,000	"	40 "	50	"	"
"	30,000	"	45 "	65	"	"
"	50,000	"	55 "	75	"	"
"	75,000 and upwards,		60 "	100	"	"

It has been ascertained by repeated tests that in Boston, the dwelling-house consumption is less than fifty, perhaps less than forty gallons per capita per day. As an example of the other extreme, — the much larger consumption in the business districts, necessary to bring up the general average to over seventy gallons, — we instance this : In a given section of the city, centrally located, there are in round numbers, 1,200 water-services, one-third of which are metered. The population by census is about 2,700. The amount of water delivered through meters alone is equivalent to 550 gallons per capita per day ; and the amount of the additional deliveries brings the average up to over 700 gallons. An explanation of this great consumption is to be found, not in the extent of the " manufactures," — as the district contains but a limited number of manufacturing establishments, — but in the fact that it includes several large hotels, restaurants, and places of public resort, and that in one way and another it provides every day for the personal requirements as to water, of probably eight or ten times as many persons as have a domicile in the territory. The fact that so large an amount of the water used is metered, and other attendant circumstances, would indicate that there was very little waste of water.

There are other sections of the city where the consumption, as related to population, would be found so much above the average of the whole city as to present an equally striking contrast with the amounts consumed in districts comprising dwellings only. Therefore, if it should be found that all residential districts were using even less than forty gallons per capita per day, the general average of seventy gallons is sufficiently explained by the exceptionally large, but legitimate, use of water in other parts of the city.

A thorough study of the causes for the apparently great consumption of water in large cities would involve inquiry relating to the manufactures, the commerce, the habits of the people, the influx of strangers, the methods of distribution, the extent and age of the pipe-system, the use of water in connection with sewerage, the extent of private sources of

supply, the use of meters, the attempts at restriction of waste, and many other topics upon which we are but partially advised. No doubt, as these cities grow, the general subject will become of such importance, in its pecuniary aspect, as to call for exhaustive inquiry, and we may then learn such facts and be able to draw such conclusions as to form some useful judgment respecting the means of controlling the consumption. At present we find everywhere expressions of inability to reduce the consumption. We may thus esteem ourselves fortunate that our local conditions produce results so well within bounds as compared with those reached in other large cities. While seeking to supply our citizens with water for all their real wants, we yet are bound, in view of the great cost of the supply, and the limited sources at command for an increase thereof commensurate with the prospective growth of the city, to use all wise measures to keep the consumption within limits of prudent and necessary use.

When the much-to-be-desired reliable meter is found, its extended use may result in some saving; the enforcement of strict regulations governing the style of permissible fixtures may be of service; and when, by and by, we approach a threatened poverty of supply, some other restrictive agencies may be found; but at present we anticipate no material reduction in our rate of consumption.

WASTE.

Our remarks under the head of "Consumption of Water" state generally what has been accomplished during the last three years in the way of restricting waste. We seem now to have reached a point where the most which can be expected is to prevent the increase of wasteful causes, and to detect, from time to time, the leaks and accidental wastes which will inevitably occur, and occasionally to discover cases of wilful waste. The system of the "Department of Inspection and Waste," adopted in 1883, and substantially continued to date, involves two forms of surveillance, viz.: that of detection of leaks and waste by the Deacon meters, and that of house-to-house inspection. The "Deacon" service proper, *i.e.*, the operation of the meters and ascertainment of locality of waste, is performed by a force specially appointed therefor, and on duty only during the summer (eight months). A certain number of the Inspectors of Waste are detailed to investigate the wastes thus ascertained, and enforce the application of remedies. The house-to-house inspection is divided into two parts, — that which is performed by inspectors detailed to act under direction of the Water Registrar, to inspect

premises for the assessment of water-taxes; and that which performs only house-to-house duty, with the single purpose of ascertaining if fixtures are in proper condition.

Thus it is that of the entire force of thirty inspectors on out-door service not more than half of them are habitually engaged in independent house-to-house inspection the year round. This number, however, is sufficient to bring up the average of visits to each house to two per year; and that, in our judgment, is sufficient. The larger part of leaks and wastes, found by house-to-house inspection, result from defective or worn-out fixtures. But where, during 1883, the returns indicated defects in twenty per cent. of the fixtures examined, there now appear at each recurring visit to be not more than five per cent.

These minor causes of waste will inevitably be developed by every periodical inspection. Fixtures will wear out or get out of order, owners will delay repairs, and small wastes will occur, which, in the aggregate, reach a considerable amount. In the present condition of our supply it is not necessary that any new measures in the way of restriction should be immediately adopted; but we feel confident that some advantage may be derived by the adoption of strict, though not oppressive, regulations respecting the character and location of service-pipes and the character of fixtures. This is a matter now engaging our attention, and in which we shall invite the coöperation of the Department of Inspection of Buildings.

A NEW RESERVOIR.

If we were certain that no accident could occur to any of our basins, or conduits, and that no misfortune could befall in respect to the water through any of those manifestations of vegetable nature which have hitherto given us occasion for alarm, we might now, in view of the fact that our apparent "safe supply" will exceed the probable demand for seven or eight years to come, rest quietly for a few years without moving further in the direction of developing the Sudbury supply. But we cannot be sure of these things. The prosperity of the city of Boston, as a whole, and the health and comfort of its individual citizens, are too important to permit us to take the future for granted. It is the part of wisdom to be prepared for any emergency. And in that direction we recommend preparations for building a new basin.

At the original taking of the Sudbury plans were formed for seven basins. Four have been built, the last one constructed requiring three years for completion. If another

shall now be begun, an equal length of time will undoubtedly be required. Meantime no added burden will fall upon the water-takers, as the growth of the city will supply the increase of revenue necessary to meet the new interest charges created. Whether, after building a fifth basin of large size, it will be necessary at once to further develop the system will be for later years to determine.

But we take occasion to make one further suggestion in this matter of additional supply. Some day the development of the system will require the acquisition of Whitehall pond. The reservoir rights in that locality are held by parties who derive no material income therefrom, and may be disposed to part with them for a reasonable price, and we should recommend their purchase. According to our present views the actual adaptation of this pond to the purposes of a reservoir, with needed enlargement and improvement, may well be among the latest of the features of development of the system. Twenty years hence may be amply early for that. But if at any time, even now, the owners of these rights will sell at a fair price, the city will do well to buy and hold till the time arrives for putting to use.

To indicate as nearly as possible what our future requirements may be, we present estimates of the probable population of Boston (excluding Charlestown), and approximate supply required, at the dates mentioned: —

Year.	Population.	Daily supply required.
1895	440,000	33,000,000 gallons.
1905	550,000	41,000,000 "
1915	660,000	49,000,000 "
1925	790,000	59,000,000 "

As our present daily supply is but 35,000,000 gallons it is apparent that in the near future further development of present sources will be necessary.

CHIMERAS.

In connection with this subject of future additions to the supply, we deem it timely to express the most decided opinion upon the demerit of the two schemes most often brought forward by those who, without knowledge or investigation, oppose what they term half-way measures, as compared with a plan of getting some "big" supply. One of these is that of taking Merrimac river, and the other of taking water from Lake Winnipesaukee. The first is condemned at the outset by the bad character of the water; and the other, if it were possible to obtain the consent of New

Hampshire, and it were practicable otherwise, by its enormous expense. The procurement of Lake Winnipesaukee would, to speak within bounds, cost twenty-five or thirty million dollars, and at once increase the water-rates to twice their present amount.

We can make a safe forecast of the future to the extent of about forty years. As the expiration of that period approaches, our successors will, no doubt, be able to make a choice from several opportunities for enlarging existing supplies, at a cost not disproportionate to the value of the acquisition, nor to the means of the city. But we venture to predict that neither the growth of the city nor any other exigency will ever produce such a state of things as to take either of the two projects alluded to out of the category of "Chimeras."

METERS.

It will be observed that we have less meters in use than at the beginning of the year. Many have been removed in consequence of complaints of stoppage or other failure of mechanism, and renewals have been made only in cases where it was absolutely necessary. Our investigations and tests have failed thus far to satisfy us that any meter in the market is wholly reliable. Even some which give little trouble, and which appear upon ordinary bench-tests to work with reasonable accuracy, are known to be faulty in some particulars; though none, so far as we know, operate to the pecuniary disadvantage of the consumer. Meanwhile we are advised that inventors are constantly seeking methods of overcoming the difficulties in the way, and it is not unlikely that a meter may yet be produced which will meet all requirements. Some late inventions have been brought to our notice which appear to have great merit. Yet the only test of value, actual service for a considerable period of time, must be applied to these, as to all others, before they can be indorsed.

No meters have been purchased from the Tremont Meter Company since June, 1885. The facts as to meters purchased of that company failing to meet the guarantee, and of efforts to secure replacement of those rejected by other "satisfactory" machines, have been before reported. We were able to secure from the Tremont Company a small number of meters in the way of "replacement;" but further transactions between ourselves and that company were brought to a close by a claim on their part that their guarantee was not applicable to the meters stated by us to be defective.

All the records and correspondence were placed in the hands of the Corporation Counsel, in order that we might be advised as to our duty in the premises. In view of the conflicting claims on both sides, and especially of the claims of the company of non-fulfilment of contract by the Water Board, it seemed that no settlement could be reached except by litigation. Thus far, however, the Tremont Company has made no attempt to enforce its alleged claims, and we have no apprehension that any such attempt would meet with success.

THE MYSTIC DEPARTMENT.

The City Council having authorized an extension of the Mystic Water Loans (originally issued at higher rates than now prevail, and on shorter time than the law permitted), such of the loans as matured during the year were extended, thus reducing materially the amounts annually required for the Sinking-Funds, and furnishing a basis for rearranging the terms of the contracts with Chelsea, Somerville, and Everett on a more equitable footing than those originally made. Accordingly new contracts were executed, taking effect July 1, and the water-rates collected in these places are now equally divided between them and the city of Boston. By the terms of these contracts we are bound to supply water from the Mystic system as it exists or may be further developed, to the extent of the surplus remaining after meeting the wants of Charlestown, the order of precedence in right to a full supply being Chelsea, Somerville, and Everett. The old contracts made by the city of Charlestown were, of course, based upon the supply owned by that city, and the new contracts have simply continued the rights to the same supply, but grant no rights to participation in any supply obtained by the city of Boston in its own name and for its own citizens.

Notwithstanding the fact that the rainfall of the year was larger than the average the supply has been barely sufficient. In fact the lake was drawn down in October to a point where pumping was necessary. With the rapid growth of the cities of Chelsea and Somerville, and the town of Everett, the consumption is steadily increasing, and the recurrence of a dry season would certainly find these communities dependent upon some other source of supply to meet their wants.

Reference to the table of analyses elsewhere shows what the quality of the water is, as compared with that of Boston and other places. We have maintained a constant

inspection of the localities offering opportunity for pollution; and our records now show very few cases where direct pollution is imminent. The possibilities of indirect pollution we cannot fully control, and these remain in sufficient number to threaten serious injury to the quality of the water.

Referring to previously expressed opinions, we have simply to repeat that the time has arrived when, with reference both to the quantity and quality of the water, a new supply should be obtained. The application of the city of Boston to the Legislature of 1886, for the water of the Shawshine, was denied. Early in the summer we formally called the attention of the authorities of Chelsea, Somerville, and Everett to their jeopardy in respect of water supply, and urged them to make an independent investigation of the subject. They acted upon our suggestion, and as a result appear to be fully convinced of the ground taken by us in their behalf before the Legislature of 1886. They have consequently joined in a renewed petition to the incoming Legislature. It would appear that the great, even vital, interest these places have in the matter should be presented in such a way as to be convincing. To Boston the Mystic supply is of minor consequence. We inherit from the city of Charlestown a possible moral obligation to maintain our friendly attitude with these communities. But they now aggregate fully twice the population of Charlestown, and their ratio of interest grows larger year by year. If, for any reason, they had desired to assume, individually or collectively, the cost, care, and responsibility of providing for the demands of the future, and to dissolve their association with Boston, we should have deemed it wise to place no obstacles in their way. Boston could contemplate the contingency of being obliged to furnish Charlestown with water (Charlestown holding but about 9 per cent. of the population of the city, taken as a whole, and having no expectation of future growth in population), without apprehension. But we do not understand that these places have any wish to enter unaided upon such a serious task. They are satisfied with their relations to us, and prefer to continue as our customers, leaving to us the management, and content that, so far as Charlestown is concerned, we may participate in the advantage of such new supply as may be granted for the general benefit of all concerned.

It should not be forgotten that, while so long as the Mystic supply is used, Boston lies under the moral obligation alluded to, we are under neither legal nor moral obligation to supply other communities with water from the Cochituate and Sudbury system. That system was originated and developed

for the city of Boston only. Not many years will elapse before its capacity will be fully tested by the wants of Boston only, and when that city will be in its own behalf searching for new means of supply. It, therefore, behooves the communities interested in the Mystic system to speedily avail themselves of an opportunity for securing an adequate safe and good supply of water, if one is to be had. Such a supply has been pointed out in the Shawshine river.

The future demands of the Mystic district are approximated as follows: —

Year.	Population.	Daily supply required.
1895	132,000	10,000,000 gallons.
1905	179,000	13,500,000 "
1915	232,000	17,500,000 "
1925	290,000	22,000,000 "

THE MYSTIC SEWER.

This expedient for removing the tannery drainage from the influents of the Mystic lake serves its purpose, but leaves upon our hands a problem of some difficulty. While we do not fully concede the correctness of statements made by some of the citizens of Medford and Arlington as to the pernicious effects of permitting the liquid part of the sewage to flow into the river below our dam, yet it must be admitted that a practicable plan of cleansing the effluent is greatly to be desired. The use of our settling-basins, and the removal of the solid matters before permitting the liquid to flow to the sea, accomplishes something; but there should be some means found, if possible, for more complete filtration or purification. We have considered several schemes, and have made experiments from which we hope to evolve a satisfactory plan, setting at rest all questions of alleged nuisance.

JAMAICA POND.

As the question of accepting the Act of the Legislature, authorizing the city to purchase the property of the Jamaica Pond Aqueduct Company, will be considered by the City Council, we deem it proper to state the reasons which have influenced our judgment in favor of this proposition.

The rights of the Jamaica Pond Aqueduct Company are derived from a charter granted when Roxbury was little more than a village, and when a few detached clusters of houses required a greater supply of water than could be secured from wells. The available supply was then even greater than it is now, as the growth of Jamaica Plain —

then a rural territory, favorably situated for the collection of water from the natural water-shed — has greatly disturbed the natural conditions, and less water is now secured. Meantime, while Roxbury grew to be a city, its demands for water could not be met; but one of the most potent facts in determining the question of annexation was the procurement of Cochituate water. So, when Roxbury became a part of Boston, the pipes of the Cochituate system were extended, not only to all the territory not covered by the Jamaica Pond Company, but necessarily through all the main avenues where the latter company had previously laid its pipes. But the sales of the Jamaica Pond Company are to-day not much greater than they were twenty years ago. They have no means of increasing their business, unless through an agency to be hereafter mentioned. Still, the franchise was of such value to the proprietors that they expended, since 1874, a large sum of money — between sixty and seventy thousand dollars — for new iron mains and for other necessary plant, in order to preserve the earning capacity of the works.

It has been said that the company has no property of real value to sell, and that if let alone their supply will gradually fall to a point below where its sale is profitable. We do not esteem this to be true; for, while the supply may become less, we think it quite possible for them to adopt methods which would for all time secure them a considerable revenue. Their latest project is to make a connection with the Dedham Water Company, and not only secure a full supply for their present wants, but possibly to enlarge their business.

Now, if the Jamaica Pond Company, or any other private corporation, could supply to any given section of the city a good quality of water, and all that is required for domestic and fire purposes within that section, it might be desirable that such a corporation should not only exist, but be encouraged; for, whatever the extent of the supply, it would reduce by so much the demands upon our public works. But the fact is that in the territory over which the Jamaica Pond water is distributed the city of Boston is also obliged to maintain practically a full service. So that we have all the plant necessary to do all the business, while another party takes a considerable part of the revenue. The amount of water supplied is so insignificant as not to be worth considering in connection with our large requirements; and we suffer the disadvantage above-named, besides having in our streets — sufficiently burdened otherwise — an unnecessary pipe

system, subject to all the contingencies of street-openings, etc. And in respect to the requirements for fire purposes, both the system and the supply are so unreliable that it is necessary for us to introduce our water into their pipes whenever a fire occurs in a place where only their pipes are located.

As to the project of connecting with Dedham and introducing Charles-river water, we assume that it will be esteemed very undesirable for many reasons. If the possibilities in respect to a reduction of our revenue be wholly ignored, the plan would simply serve to perpetuate the objectionable features of the present double system of supply.

In the correspondence printed in the Appendix may be found a statement of the terms on which the Jamaica Pond Company will sell; and also what will be the cost of combining the Jamaica Pond distribution with our own. The assessed value of the property of the company (not including its mains) is $31,000. Its revenue is about $15,000 per annum.[1] What its net income is we are unable to state; but, it is known that its stock and obligations are held by a few persons, and that in some form they obtain a considerable income. The rates for water charged by the Jamaica Pond Company have heretofore been somewhat less than those of the city; but, under our new scale of assessments, we judge that there would be no material difference. We estimate the income, at our rates, at $17,000; so that, if the city purchases the property (at, say $100,000), and expends $20,000 for combining the systems of distribution, the outgo of the city would be the interest on these sums, the loss of taxes, cost of maintenance, and loss of occasional revenue from sale of water, — say an average total of not more than $8,000 per year. It would, therefore, appear that there would accrue a net revenue, for the general benefit of the whole body of water-takers, of $9,000 or $10,000 a year. Viewed, then, as a financial operation only, it is very much to our advantage.

If the City Council shall accept the act authorizing the purchase, it will be for them to determine which of the offers made by the Jamaica Pond Company it is desirable to accept. These offers, though made a year ago, and with conditions, are still open.

Accompanying this report will be found a plan showing the lines of pipe, both of the city system and of the Jamaica Pond Company, in the localities where the latter are laid.

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[1] See Appendix.

The letter from the City Engineer sufficiently indicates the value of the latter system, both in itself and in its relation to our own.

The reports of the City Engineer, Water Registrar, and Division Superintendents are appended.

HORACE T. ROCKWELL,
WILLIAM B. SMART,
THOMAS F. DOHERTY,
Commissioners.

General Statistics.

SUDBURY AND COCHITUATE WORKS.	1884.	1885.	1886.
Daily average consumption in gallons	25,090,500	25,607,200	26,627,900
Daily average consumption in gallons per inhabitant	71.9	72.4	74.3
Daily average amount used through meters, gallons	5,171,120	6,186,668	6,373,200
Percentage of total consumption metered	20.6	24.2	23.9
Number of services	50,632	51,810	53,400
Number of meters and motors	4,666	4,417	3,763
Length of supply and distributing mains, in miles	388.5	400	414
Number of fire-hydrants in use	4,573	4,681	4,806
Yearly revenue from water-rates	$1,203,192 55	$1,239,757 99	$1,206,064 69
Yearly revenue from metered water	$378,484 75	$452,961 60	$400,706 85
Percentage of total revenue from metered water,	31.5	36.5	33.2
Cost of works on May 1, 1884, and Jan. 1, 1886, 1887	$17,775,955 68	$18,567,279 19	18,973,616 03
Yearly expense of maintenance	$336,578 36	$321,137 26	$336,507 37
MYSTIC WORKS.			
Daily average consumption in gallons	6,209,700	6,737,350	7,399,800
Daily average consumption in gallons per inhabitant	64.5	67.9	72.5
Daily average amount used through meters, gallons	869,246	1,012,755	1,117,600
Percentage of total consumption metered	14.0	15.0	15.1
Number of services	14,939	15,928	16,110
Number of meters and motors	571	594	469
Length of supply and distributing mains, in miles	129.2	131.0	133.2
Number of fire-hydrants in use	794	781	818
Yearly revenue from water-rates	$262,243 50	$276,557 60	$249,609 62
Yearly revenue from metered water	$63,627 39	$74,128 87	$69,330 48
Percentage of total revenue from metered water,	24.3	26.8	27.8
Cost of works on May 1, 1884, and Jan. 1, 1886 and 1887	$1,648,452 35	$1,656,805 39	$1,657,458 97
Yearly expense of maintenance	$128,126 40	$122,858 00	$134,439 43

Earnings and Expenditures.

The total receipts of the Cochituate Water-Works from all sources for the year ending December 31, 1886, were as follows, viz. : —

Income from sales of water	$1,206,064 69
Income from shutting off and letting on water, and fees	3,202 20
Elevator, fire and service-pipes, sale of old materials, etc.	31,296 40
	$1,240,563 29

The total expenditures of the Cochituate Water-Works for the year ending December 31, 1886, were as follows, viz. : —

Current expenses	$336,507 37	
Refunded water-rates	702 69	
Transferred to City Collector's Department	2,500 00	
Interest on funded debt	680,993 51	
		1,020,703 57
Balance Dec. 31, 1886		$219,859 72

From this apparent balance is to be deducted the amount required for Sinking-Fund.

The total receipts of the Mystic Water-Works, from all sources, for the year ending December 31, 1886, were as follows, viz. : —

Income from sales of water	$249,609 62
Income from shutting off and letting on water, and fees	767 25
Service-pipes, repairs, etc.	1,856 59
Interest on cost of Chelsea pipes	2,330 42
	$254,563 88

The total expenditures of the Mystic Water-Works for the year ending December 31, 1886, were as follows : —

Current expenses	$134,439 43	
Interest on funded debt	45,323 75	
Amounts carried forward,	$179,763 18	$254,563 88

Amounts brought forward,	$179,763 18	$254,563 88
Refunded water-rates . . .	177 42	
Amount paid Chelsea, Somerville, and Everett, under contract	42,669 63	
		222,610 23
Balance Dec. 31, 1886 . . .		$31,953 65

From this apparent balance is to be deducted the amount required for Sinking-Fund.

OUTSTANDING LOANS.

The outstanding Cochituate Water Loans at this date, Jan. 1, 1887, *exclusive* of the Additional Supply, are as follows:—

5 per cent. Sterling Loan (£399,500) . .	$1,947,273 98		Due Oct. 1, 1902
5 per cent. Gold Loans	100,000 00	$100,000	Due April 1, 1906
5 per cent. Cur. Loan	1,000 00	1,000	Due Oct. 1, 1907
6 per cent. Loan .	4,253,000 00	500,000	Due Dec. 12, 1897
		450,000	Due June 16, 1898
		540,000	Due Oct. 3, 1898
		250,000	Due April 27, 1899
		625,000	Due Jan. 1, 1901
		688,000	Due April 1, 1901
		330,000	Due July 1, 1901
		413,000	Due April 1, 1903
		38,000	Due April 1, 1904
		161,000	Due Jan. 1, 1905
		142,700	Due April 1, 1905
		6,000	Due Oct. 1, 1905
		82,550	Due Jan. 1, 1906
		8,750	Due April 1, 1906
		4,000	Due Oct. 1, 1906
		8,000	Due Jan. 1, 1907
		5,000	Due April 1, 1907
		1,000	Due July 1, 1907
4 per cent. Loan .	1,188,000 00	280,000	Due April 1, 1910
		111,000	Due July 1, 1913
		257,000	Due Jan. 1, 1914
		23,000	Due Oct. 1, 1915
		50,000	Due Jan. 1, 1915
		144,200	Due April 1, 1915
		58,000	Due Jan. 1, 1916
		28,500	Due April 1, 1916
		236,300	Due Oct. 1, 1916
$3\frac{1}{2}$ per cent. Loan .	300,000 00	50,000	Due April 1, 1915
		50,000	Due Oct. 1, 1915
		100,000	Due Jan. 1, 1916
		75,000	Due July 1, 1916
		25,000	Due Oct. 1, 1916
	$7,789,273 98		

The outstanding Mystic Water Loans at this date, Jan. 1, 1887, are as follows: —

6 per cent. currency Mystic Water Loans	$491,000 00	$50,000	Due Oct. 1,	1887
		3,000	Due April 1,	1888
		100,000	Due July 1,	1890
		51,000	Due Jan. 1,	1891
		139,000	Due July 1,	1891
		67,000	Due Jan. 1,	1892
		42,000	Due July 1,	1892
		39,000	Due July 1,	1893
5 per cent. currency Mystic Water Loans	$108,000 00	6,000	Due Oct. 1,	1893
		102,000	Due April 1,	1894
3¼ per cent. Cur. Loans	35,000 00	35,000	Due April 1,	1896
3½ per cent. Cur. Loan	60,000 00	60,000	Due Oct. 1,	1896
3½ per cent. Mystic Sewer Loan	$130,000 00	130,000	Due April 1,	1916
4 per cent. Loan	15,000 00	15,000	Due Oct. 1,	1913
	$839,000 00			

The following statement shows the appropriations by the City Council for an additional supply of water, with the loans issued to meet them, and the amount of expenditures to Jan. 1, 1887: —

APPROPRIATIONS.

Oct. 21, 1871.	Transfer from Reserved Fund	$10,000 00
Apr. 12, 1872.	Order for Treasurer to borrow	100,000 00
Apr. 11, 1873.	" " "	500,000 00
Feb. 26, 1875.	" " "	1,500,000 00
July 1, 1876.	" " "	2,000,000 00
Apr. 20, 1878.	" " "	600,000 00
Apr. 11, 1879.	" " "	350,000 00
Aug. 17, 1881.	" " "	324,000 00
June 2, 1883.	" " "	621,000 00
Oct. 14, 1884.	" " "	150,000 00
Total appropriations to April 30, 1886		$6,155,000 00

Oct. 1, 1875.	Premium on $1,000,000 bond, under order of Feb. 26, 1875	$83,700 00	
April 1, 1876.	Premium on $452,000 bonds, under order of Feb. 26, 1875	47,786 80	
Oct. 1, 1876.	Premium on $2,000,000 bonds, under order of July 1, 1876	221,400 00	
			352,886 80
Amount carried forward,			$6,507,886 80

Amount brought forward,		$6,507,886 80
EXPENDED.		
1871–72	$2,302 81	
1872–73	61,278 83	
1873–74 including $20,897.50, discount on bonds sold, January, 1874	114,102 77	
1874–75	224,956 68	
1875–76	783,613 49	
1876–77	1,924,060 24	
1877–78	1,257,715 26	
1878–79	635,658 08	
1879–80	213,350 97	
1880–81	97,406 78	
1881–82	35,677 98	
1882–83	167,621 43	
1883–84	423,625 79	
1884–85	276,292 13	
1885–86	139,187 68	
May 1, 1886, to Jan. 1, 1887	111,330 14	
		6,468,181 06
Balance of appropriations unexpended January 1, 1887,		$39,705 74

The outstanding loads on account of Additional Supply of Water, on Jan. 1, 1887, are as follows: —

4 per cent. Loans	$1,725,000	$324,000	Due April 1, 1912
		82,000	Due July 1, 1908
		588,000	Due April 1, 1908
		336,000	Due Oct. 1, 1913
		209,000	Due Jan, 1, 1914
		18,500	Due April 1, 1914
		16,000	Due Oct. 1, 1914
		1,500	Due April 1, 1915
		100,000	Due April 1, 1916
		50,000	Due April 1, 1916
5 per cent. Gold Loans	3,452,000	1,000,000	Due Oct. 1, 1905
		452,000	Due April 1, 1906
		2,000,000	Due Oct. 1, 1906
5 per cent. Cur. Loan	12,000	12,000	Due April 1, 1908
6 per cent. Loans	644,000	100,000	Due July 1, 1902
		492,000	Due April 1, 1903
		8,000	Due Jan. 1, 1904
		44,000	Due July 1, 1905
4½ per cent. Loan.	268,000	268,000	Due Oct. 1, 1908
	$6,101,000		

Total Water Debt of the City of Boston January 1, 1887.

Cochituate	$13,890,273 98
Mystic	839,000 00
	$14,729,273 98

Cost of Construction of the Cochituate Water-Works to January 1, 1887.

Cost of Water-Works to January 1, 1850, as per final report of Water Commissioners	$3,998,051 83
Extension to East Boston	281,065 44
Jamaica-pond aqueduct	13,237 50
New dam at Lake Cochituate	10,940 08
Raising lake two feet, including damages	28,002 18
Dudley pond, lower dam, and making-connections with lake	18,982 23
New main from Brookline reservoir	304,991 83
Land and water rights and land damages since January 1, 1850	49,486 17
New pipe-yard and repair-shop	25,666 51
Upper yard, buildings, etc.	9,165 63
New water-pipes, East Boston	20,999 43
New main, East Boston	24,878 08
Pumping-works at Lake Cochituate	23,577 69
High-service, stand-pipe, engine-house, and engines	103,829 53
High-service, South Boston	27,860 29
Chestnut-Hill reservoir, including land	2,461,232 07
Parker-Hill reservoir	228,246 17
Charles-river siphon	26,532 35
Keeper's house, Parker Hill	2,764 90
Temporary high-service, Brighton	7,865 86
New stable at Chestnut-Hill reservoir	8,103 55
Pegan dam, Natick	1,394 06
Willow dam, Natick	1,567 29
High-service, East Boston	22,960 07
New main from Chestnut-Hill reservoir	341,702 28
New high-service works	304,115 06
Cost of laying main pipe for extension in Roxbury, Dorchester, Brighton, and West Roxbury Districts	1,758,512 22
Additional supply of water, including land damages and all expenses	6,468,181 06
Cost of laying main pipe since January 1, 1850	2,147,982 35
Extension of mains, etc. (from loans)	251,722 32
	$18,973,616 03

Cost of Construction of the Mystic Water-Works to January 1, 1887.

Salaries	$17,644 61
Engineering	33,746 87
Land damages	91,855 38
Reservoir	141,856 26
Dam	17,167 26
Conduit	129,714 30
Engine-house, coal-shed, and chimney	36,112 99
Engines	150,096 70
Grubbing pond	9,393 26
Iron pipes	108,437 10
Iron pipes, trenching	61,029 59
City distribution	162,335 23
Hydrants	19,976 21
Stopcocks	19,262 52
Miscellaneous items	14,012 51
Roadway and bridge	3,529 22
Lowering Mystic river	3,012 06
Inspections	1,824 79
Service-pipes and meters	133,858 70
Hydrants for Somerville and Medford	2,653 08
Somerville distribution	2,492 10
Dwelling-house for engineer and fireman (pumping-station)	4,871 02
Chelsea extension	37,347 86
Medford extension	3,997 41
Drinking-fountains	1,415 05
New line of supply main	203,050 09
Stable and pipe-yard	8,964 64
Extension of engine-house and boiler	33,727 43
New force-main	9,875 17
Mystic sewer	136,245 70
New stable engine-house	1,767 39
Additional force-main	24,882 96
Temporary pumping-works	6,905 15
New work-shop	3,000 00
Cost of laying main pipe since 1873	21,398 36
	$1,657,458 97

REPORT OF CITY ENGINEER.

Office of City Engineer,
City Hall, Boston, January 21, 1887.

Col. H. T. Rockwell, *Chairman Boston Water Board:*—

Sir, — In accordance with the requirements of the revised ordinances I respectfully submit the following report on the condition of the Water-Works: —

Yield of the Sources of Supply.

The rainfall of the year 1886 was larger than that of any previous year since 1878, and the percentage received in the storage-reservoirs was above the average. During the summer, however, the rainfall was small, and the percentage collected was less than the average. In consequence of this unequal distribution of the rainfall the supply from the Mystic works was insufficient, and, for a short time, the temporary pumps were used to raise the water from the lake into the conduit.

In February occurred the greatest freshet of which we have any well-authenticated records. Between February 10 and 13 the following rainfalls were recorded at different points on the water-sheds of our sources of supply: —

Framingham, 4.64 inches.
Westborough, 4.63 inches.
Lake Cochituate, 4.95 inches.
Mystic Lake, 5.64 inches,
Winchester, 5.45 inches.

Previous to the beginning of the rain the ground was covered with snow, which has been estimated as equivalent to two inches of rain; and the weather during the freshet was mild, so that most of the snow was melted and entered the streams.

The following table shows the yield of the different sources of supply from February 12 to 18.

	Sudbury. Gallons.	Cochituate. Gallons.	Mystic. Gallons.
Feb. 12	942,900,000	335,600,000	322,500,000
Feb. 13	2,006,500,000	509,900,000	687,800,000
Feb. 14	1,294,900,000	281,400,000	576,700,000
Feb. 15	841,900,000	198,700,000	363,100,000
Feb. 16	534,800,000	144,100,000	239,700,000
Feb. 17	429,300,000	80,700,000	134,600,000
Feb. 18	357,600,000	123,400,000	95,260,000
Totals	6,407,900,000	1,673,800,000	2,419,600,000

The amount collected on each of these water-sheds during the week was nearly one-fourth of the amount collected during the entire year.

On the Sudbury river the yield was equal to 4.83 inches of rainfall on the entire water-shed; on the Cochituate water-shed 5.10 inches, and on the Mystic 5.18 inches. This freshet was the cause of great damage throughout New England, but no damage was done to any portion of the works connected with the water supply. In the report of the Superintendent of the Western Division will be found a record of the head of water existing at the different culverts and bridges on the line of the Sudbury and Cochituate aqueducts.

SUDBURY–RIVER RESERVOIRS AND LAKE COCHITUATE.

Although Reservoir No. 3 has been empty during the greater portion of the year the increase of storage capacity, due to the completion of Reservoir No. 4, has enabled these works to furnish an ample supply of water of good quality. The fluctuations of the different reservoirs are graphically shown on Plate, facing page 50.

Reservoir No. 1.— On account of the work being done at Reservoir No. 3 the water in this reservoir was kept between four and five feet below the level of the flash-boards from the middle of April to the latter part of November. Water was wasted at Dam No. 1 from January 1st to June 4th, from December 2d to 8th, and from December 19th to the present time. Water was taken from this reservoir for the supply of the city from June 4th to June 9th.

Reservoir No. 2.— Was full and overflowing from January 1st to June 21st. During July its surface lowered rapidly, and on Aug. 5th it was 10.72 feet below the crest of the dam.

It then rose about two feet, and remained about grade 157 until the beginning of October, when it was lowered to 156.

Copious rains in the latter part of October and during the month of November filled the reservoir, so that on November 23d water was wasted over the crest of the dam. The reservoir is now full and overflowing.

Reservoir No. 3.— During the year 1885 surveys and estimates were made, with the view of doing by contract the greater portion of the excavation required to improve this reservoir, and remove the shallow flowage; and on December 10, 1885, the emptying of the reservoir was begun, in order that the ground-water might have ample time to drain off before beginning the work in the spring.

On April 6, 1886, proposals were received for the removal of about 130,000 cubic yards of mud and gravel in the portion of the reservoir north of the Old Colony R.R. The work was divided into five sections, as shown in the following table, which gives the principal facts relating to each: —

Section.	Contractor.	Price per cubic yard.	Cubic yards moved.	Work completed.	Amount of contract.	Number of bids.	Range of bids.
A.	Neil McBride	$0.27	25,331	Sept. 20	$6,839 37	11	27 to 75c.
B.	" "	0.27	16,640	July 19	4,492 80	11	27 to 65c.
C.	" "	0.24	15,512	Aug. 7	3,722 88	12	24 to 75c.
D.	Silas H. Munson	0.29	41,542	Sept. 8	12,047 18	12	27 to 65c.
E.	" "	0.31	40,637	Oct. 7	12,597 47	11	27 to 65c.

While this work was in progress plans and specifications were prepared for similar work in the portion of the basin south of the Old Colony R.R. And on June 1st proposals were received for work embraced in the following statement: —

Section.	Contractor.	Price per cubic yard.	Cubic yards moved.	Work completed.	Amount of contract.	Number of bids.	Range of bids.
F.	Neil McBride	$0.23	19,486	Sept. 18	$4,481 78	9	23 to 33c.
G.	J. R. Rooke	0.24	13,770	" 21	3,304 80	9	24 to 34c.
H.	Joseph McNamara	0.257	12,320	" 8	3,166 24	9	25.7 to 34c.
I.	" "	0.247	15,843	" 5	3,913 22	9	24.7 to 34c.
J.	" "	0.225	9,448	July 29	2,135 80	9	22.5 to 33c.

About 100 horses and 250 men were employed by the contractors in executing these contracts, and the work was all completed in good season and in a satisfactory manner. The result accomplished by this work has been the deepening of the shallow portions, so that when the reservoir is full there is nowhere around the borders less than 10 feet of water.

The mud, stumps, and other objectionable materials were deposited in the shallow portions of the reservoir, thus raising these portions above the water-line; the gravel excavated was placed in front of these deposits, leaving clean gravel slopes of about three horizontal to one perpendicular, exposed to the water.

The upper and narrow portion of the reservoir was very shallow, composed of meadows, and covered with a rank growth of vegetation. The improvement of this section was done by day-labor, and consisted in digging a channel down to the gravel, and filling up the sides with clean gravel to one foot above the highest flow-line. The water now varies from eight to fifteen feet in depth for about 3,500 feet from the influent end of the reservoir.

Including some work done in 1883 about 56,000 cubic yards of material have been excavated in this section, and 6,200 square yards of heavy riprap and paving put in place.

In the lower portion of the reservoir, near the dam, was a large swamp, which, before the reservoir was built, was covered by a heavy growth of trees; the stumps still remained, and it was decided to remove them.

Some 517 stumps were removed between May 20 and June 25 by J. R. Rooke for $1.00 each. On July 8 a contract was made with Louis La Fontaine for the removal of stumps at $1.98 each. This contract was completed about the last of August, — 6,888 stumps having been removed at a cost $8,351.82; 1,092 stumps have since been removed by A. Saucier at $0.97 each.

The work of improving Reservoirs 2 and 3 in accordance with the recommendation of the Sanitary Commission, and the appropriation of the City Council, is now practically completed. The total cost of work done to date is $203,482.78.

On October 9 the work was completed and the gates closed; the water at that date standing at grade 155.06 above tide marsh level. On December 27 the level of the water was at grade 175.51, and water was wasting over the crest of the dam.

Reservoir No. 4. — At the date of the last annual report this reservoir was being filled for the first time, and on January 1, 1886, its surface was at grade 193.65 or 26.65

feet above the lower effluent pipe. On February 12 it had risen to grade 202.87, and between February 12 and 15 the freshet raised the reservoir about eight feet; the waste gate was then opened, and the level of the water maintained at about grade 210, until the middle of March, when the gates were closed, and on April 1 the reservoir was full for the first time.

Until August 4 it remained near high-water mark, at which time it was drawn upon for the city's supply, and on November 1 its surface had been lowered seventeen feet to grade 197.36. During November and December the reservoir has been slowly filling, and on January 1, 1887, it was 204.93 feet above tide marsh level, or about ten feet below the crest of the overflow.

Considerable work has been done in completing the grading of the dam, sodding and sowing the embankments and planting trees.

The leakage from the dam has been collected in tile drains, and conveyed to weirs, for the purpose of keeping a record of its amount.

Farm Pond. — This pond was kept at or near high water mark from January 1 until March 24, 1886, when it was drawn down to facilitate the work of building the Farm-pond conduit. It was kept about four feet below high water until October 27, when it rose slowly to 145.90 on November 19, and then more rapidly to 149.23 on December 1, near which level it still remains. Water for the city's supply was drawn from this pond until July 9, when the new conduit was completed, and water run through it to Chestnut-Hill reservoir, for a few days, after which the supply was again taken from the pond until September 9, when algæ made their appearance in the pond, and the supply was again taken through the conduit. On October 4 water was taken from the pond, and the supply has since been taken from that source, except from November 21 to 29. The Framingham Water Company have drawn from the pond during the year 76,600,000 gallons, — a daily average of 209,860 gallons.

Lake Cochituate. — On Jan. 1, 1886, the surface of the lake was 2.89 feet below high-water mark. On January 29 waste was commenced at the outlet dam and continued until March 5. Also during the greater portion of the time from March 22 to April 19.

The lake surface remained near high-water mark until June 1, from which time until October 27 it gradually lowered, when it was 127.60 above tide marsh level; It has been slowly raising since December 9, and on January 1,

1887, was 129.77 feet above tide marsh level or 1.70 feet lower than at the beginning of the year.

Repairs have been made at the outlet dams, detailed reports of which will be found in the report of the Superintendent of the Western Division. Owing to the efforts which have been made to remove all sources of pollution from Pegan Brook, the water of that stream is now bright and clear, and it is believed that no sewerage now enters the brook. No water has been run into Lake Cochituate from the Sudbury river during the year. Dudley Pond is now nearly full, and no water has been drawn from it.

The following table shows the heights of the different reservoirs on the first of each month: —

	Res. No. 1. Top of flash-boards, 159.29.	Res. No. 2. Top of flash-boards, 167.12.	Res. No. 3. Crest of Dam, 175.24.	Res. No. 4. Crest of overflow, 214.21	Farm Pond.	Lake Cochituate. Top of flash-boards, 134.36.
Jan. 1, 1886.	158.02	166.11	158.85	193.65	149.33	131.47
Feb. 1, " .	158.12	166.23	158.35	200.99	149.26	132.90
Mar. 1, " .	158.15	166.32	158.63	210.05	149.24	133.14
Apr. 1, " .	156.34	166.45	156.85	214.71	147.64	134.05
May 1, " .	155.29	167.23	155.35	214.47	145.01	134.20
June 1, " .	155.34	167.08	155.40	214.45	144.91	133.98
July 1, " .	154.95	165.50	154.60	214.61	144.97	132.65
Aug. 1, " .	154.50	157.40	154.51	214.58	145.11	131.36
Sept. 1, " .	154.33	157.07	154.36	209.14	145.25	130.19
Oct. 1, " .	155.06	157.25	155.11	204.13	145.35	128.90
Nov. 1, " .	154.29	158.20	158.81	197.36	145.63	127.64
Dec. 1, " .	157.44	165.93	166.83	200.08	149.23	127.84
Jan. 1, 1887.	157.98	166.13	175.54	204.93	149.28	129.77

Water has been drawn from the Sudbury-river reservoirs for the supply of the city as follows: —

Jan.	1 to Feb. 13,	from	Reservoir No. 2.	
Feb.	15 to Feb. 19,	"	Farm Pond.	
Feb.	19 to March 22,	"	Reservoir No. 2.	
March	23 to April 14,	"	Farm Pond.	
April	14 to June 4,	"	Reservoir No. 2.	
June	4 to June 9,	"	"	Nos. 1 and 2.
June	9 to July 17,	"	"	Nos. 2 and 3.
July	17 to Nov. 18,	"	"	No. 2.
Nov.	18 to Nov. 22,	"	"	Nos. 2 and 3.
Nov.	22 to Jan. 1, '87,	"	"	No. 2.

FARM POND CONDUIT.

JAN. 1887.

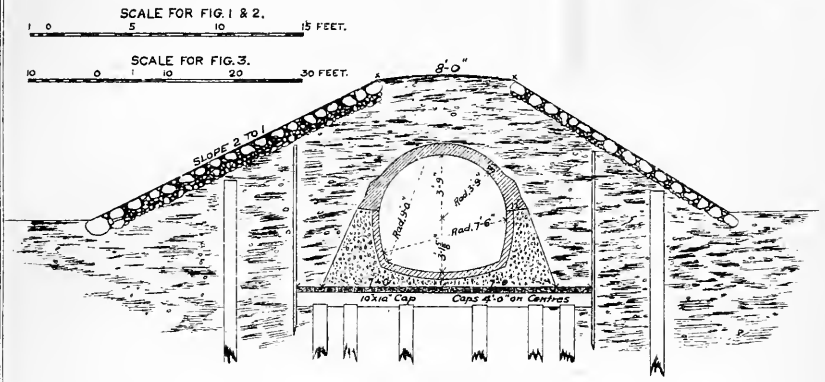


FIG. 1.

SECTION OF CONDUIT ACROSS POND
ON PILE FOUNDATION.

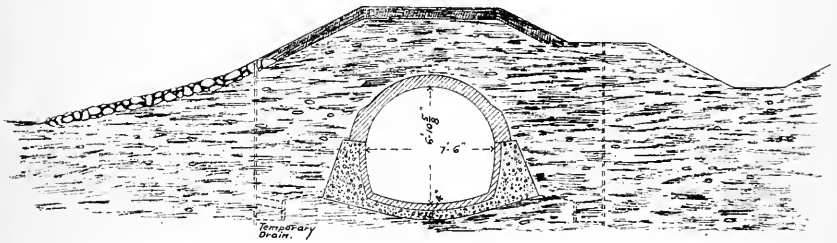


FIG. 2.

SECTION OF CONDUIT ON SHORE.

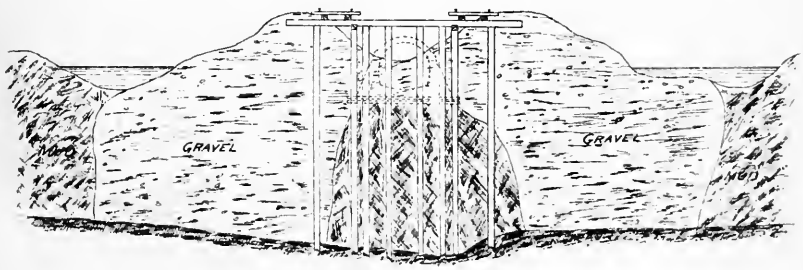


FIG. 3.

SECTION AT STATION 31 + 25.
SHOWING RAILROAD TRESTLE AND GRAVEL FILLING.

Rolletype Printing Co. Boston

Farm-Pond Conduit.

The conduit across Farm Pond, which has been in process of construction since the winter of 1883, was completed and used for the first time on July 9, 1886. Previous to its construction all the water from the Sudbury-river reservoirs was obliged to pass through this pond on its way to the city, and in 1881 the cucumber taste in the water of the Sudbury supply was decided to be caused by the presence of a fresh water-sponge, "spongilla lacustius," in Farm Pond. It was therefore decided to construct a conduit across the pond, which would allow the water from the Sudbury-river reservoirs to be sent to Chestnut-Hill reservoir, without mingling with the pond-water. This connection was a part of the original design of the system, but it was not expected that its construction would be so soon required. The conduit is of brick and concrete masonry, built along the shore of the pond for a distance of 2,100 feet, thence across the pond for a further distance of 1,700 feet. The shore section of the conduit, Figure 2, rests upon a foundation of sand or gravel, and presented no special difficulties of construction; across the pond, however, the hard bottom was from 11 to 55 feet below the level of the pond, overlaid by from 1 to 30 feet of mud, and in several places by 15 feet of watery quicksand.

In order to secure a suitable foundation for this section of the conduit it was decided by Mr. H. M. Wightman, then City Engineer, to drive piles through the mud and quicksand into the hard bottom; and on these piles, which were to be used to support the masonry conduit, a trestle to support two railroad tracks was built, about four feet above the water level. Gravel was then dumped on each side of the trestle, displacing the surrounding mud and a solid bank of gravel built up from the hard bottom to above the water surface as shown by Figure 3. The earth around the pile-trestle was then excavated, and the piles cut off about thirteen feet below the top of the trestle, and capped with 10 × 10-inch spruce timbers; the caps were then covered by a flooring of 4-inch spruce planks upon which the conduit of concrete and brick masonry was constructed as shown by Figure 1. The pile-trestle was built by George H. Cavanagh, at a cost of $26,170.60. This contract was awarded in October, 1883, and the work was completed in April, 1884. The contract for the filling was awarded to Parker & Sylvester, in February, 1884; work was commenced on March 14, and completed on July 11, — 59,010 cubic yards of material having been deposited at a cost of $0.47 per cubic yard.

On August 4, 1884, proposals were received for the con-

struction of the masonry conduit, and on August 20 a contract was made with G. M. Cushing, of New York, for doing the work. The work was in process of construction by this contractor during 1884 and 1885; but, owing to his failure to complete his contract, within the specified time, the Water Board, on December 1, 1885, took possession of the work.

On April 13, 1886, the work of completing the conduit by day-labor was begun, and on July 9 the work was finished, and the conduit placed in service. The total cost of the work was $157,837.97.

Aqueducts and Distributing Reservoirs.

Both the Sudbury-river and Cochituate aqueducts have been in service 353 days during the year. The former has delivered into Chestnut-Hill reservoir 5,267,600,000 gallons, equal to an average daily supply of 14,431,800 gallons, while 4,432,536,000 gallons, equal to 12,143,900 gallons per day, have been drawn from Lake Cochituate.

Both aqueducts were cleaned twice during the year, and the details of the work will be found in the report of the Superintendent of the Western Division. From January 1 to August 3 the water in the Cochituate aqueduct was five and one-half feet in depth. From August 3 to 6 the water was shut off for the purpose of cleaning the aqueduct, and from August 6 to December 23 the depth of water was maintained at five feet.

The Chestnut-Hill, Brookline, Parker-Hill and East Boston reservoirs are in good condition. Improvement has been made in the appearance of the grounds at Chestnut Hill and Brookline by the removal of fences.

The average monthly and yearly heights of all the reservoirs is shown by the table on page 50.

High-Service Pumping-Stations.

The daily average amount of water pumped at the Highland station has been 2,918,400 gallons, an increase of 10.8 per cent. from that of the year 1885. This is due to additions which have been made to the territory supplied by these works, both by the laying of new mains and by the changing of a section of the Highland District from low to high-service supply. The Worthington engine has been in use 7,703 hours, 25 minutes, an average of about 21 hours per day, and has pumped 1,055,116,000 gallons. The Boston Machine Company engine was used for 168 hours to assist in filling the Fisher-Hill reservoir, and pumped 10,105,000 gallons.

Total coal consumed, 1,981,200 lbs., of which 14.9 per cent. were ashes and clinkers.

Average lift, 111.65 feet.

Quantity pumped per pound of coal, 537.7 gallons.

Average duty (no deductions), 50,065,200 ft.-lbs. per 100 lbs.

Cost of Pumping.

Salaries	$4,368 47
Fuel	4,033 00
Repairs	350 55
Oil, waste, and packing	150 49
Small supplies	171 46
Total	$9,073 97

Cost per million gallons raised one foot high, 7.63 cents.

The daily average amount pumped at the East Boston station, for the supply of the high service of that district, has been 310,455 gallons.

At the Brighton Pumping-station the amount pumped has been about 250,000 gallons per day.

New High-Service Works.

Messrs. Moulton and O'Mahony, the contractors for the Fisher-Hill reservoir, commenced operations for the season on April 10.

The work previously done consisted in the removal of loam from the site of the reservoir. The work of construction has been carried on during the entire season, and in order to protect the work from the action of the frost the reservoir has been filled to a depth of about 17 feet. The masonry gate-chamber has been completed, with the exception of the gates and superstructure; the excavation and the reservoir banks are nearly completed, and about one-half of the puddle and concrete on the inner slope is in place.

The total value of work done to November 27, when work ceased for the season, was $52,821.15, or about 70 per cent. of the total amount of the contract. The work will probably be completed by July 1, 1887. The laying of the force and supply mains was commenced by the Superintendent of the Eastern Division on April 20, and continued until December 7. Ten thousand and eighteen feet of 30-inch, and 2,096 feet of 24-inch pipe have been laid. This work is now nearly finished.

Plans for the pumping-station and connections at Chestnut-

Hill reservoir are now being prepared, and the work will be commenced as soon as possible, in order that the pumping machinery, for which a contract has been made with the Holly Manufacturing Co., of Lockport, N.Y., may be erected, and the works completed and placed in operation during the present year.

West Roxbury High-Service.

The commission appointed by the mayor to consider the subject of the high-service water supply system of the city, in their report dated August 31, 1885 (City Document 122, 1885), recommended the building of a special system for the supply of the territory in the West Roxbury District, lying above a grade of 170 feet above tide marsh level, which could not be supplied from either Parker or Fisher-Hill reservoirs. By an order of the City Council, approved June 10, 1886, the Water Board were authorized to construct these works at an expense not exceeding $45,000. Plans and specifications were at once prepared for the work, and the following contracts were awarded: —

August 2, Blake Manufacturing Co., pumps and boilers, $2,172.

August 26, G. L. Eldridge, pumping-station and chimney, $5,081.

September 7, E. Hodge & Co., wrought-iron reservoir, $2,700.

The concrete foundation for the reservoir and the laying of the 12-inch force and supply-main, 8,000 feet in length, were done by day-labor. On December 23 the works were so far completed as to be placed in operation.

The pumping-station is a brick building, located on the corner of Washington street and Metropolitan avenue, and contains two duplex high-pressure pumps of the Knowles pattern, each of about 400,000 gallons' capacity per twenty-four hours, and two upright tubular boilers each 42 inches in diameter, containing 85 two-inch tubes six feet long. The reservoir or tank is situated on the summit of Bellevue Hill, which is the highest land within the city limits. It is 24 feet in diameter, 40 feet high, and contains, when the water is within three feet of the top, 125,000 gallons.

The reservoir is located upon land which was given to the city for park purposes, and it is intended to enclose and protect the tank by a building designed to serve as an observatory from which can be obtained a view of the surrounding country.

Mystic Lake.

On January 1, 1886, the lake was about one foot below high-water mark, and water was wasting over the outlet dam. Waste was continued until May 23, with the exception of a few days in April.

The lake surface was gradually lowered during the summer, and early in the fall it became evident that the temporary pumps at the lake would be needed to furnish a supply to the conduit. On October 20 the lake was 8.38 feet below high-water mark or about 2.79 feet above the conduit invert. On that date the pumps were started and continued in use until November 7, when, the lake having risen about twelve inches, their use was discontinued. On December 1 the lake had risen to grade 3.02 above tide marsh level, or 3.98 feet below high water; and on December 25 waste began at the overflow, and has continued to the present time.

Advantage was taken of the low stage of the lake to clean the shores at the upper end of the lake, and in Wedge Pond also to rebuild the northerly abutment of Bacon's bridge. In the spring a new and very substantial fish-way was constructed at the dam to replace the old one which was carried away by the freshet of Febuary 12–14, 1886.

Mystic–Valley Sewer.

The use of the sewer and the treatment of the sewage has been continued in the same manner as during the past few years.

Experiments are now being made in purifying the sewage, which it is hoped may lead to some practical result.

Mystic Conduit and Reservoir.

The conduit has been twice cleaned during the year and is now in good condition. The concreting of the gutters around the reservoir has been completed.

Mystic Pumping-Station.

The detail of work done by the engines at this station is shown by the table on page 52.

Engine No.	1	was in use	155	hours			pumping	27,557,500	gallons.
"	" 2	"	" 839	"	35	min.,	"	163,986,000	"
"	" 3	"	" 8,283	"	15	"	"	2,509,132,800	"
Total amount pumped								2,700,676,300	"
Total amount of coal consumed								5,869,500	lbs.

Per centage of ashes and clinkers 8.8.
Average lift, 148.82 feet.
Quantity pumped per pound of coal, 460.1 gallons.
Average duty of engines (no deductions), 57,108,200 ft.-lbs. per 100 lbs. of coal.
Daily average amount pumped, 7,399,100 gallons, an increase of 9.8 per cent. from that of the year 1885.

Cost of Pumping.

Salaries	$8,465 36
Fuel	10,113 24
Oil, waste, and packing	1,564 89
Repairs	1,306 06
Small supplies	189 60
Total	$21,639 15

Cost per million gallons raised one foot high, 5.384 cents.

The low-pressure steam cylinder on Engine No. 2, which has been cracked for a number of years, has been replaced by a new one, and the air-pumps on both 1 and 2 have been repaired.

CONSUMPTION.

The daily average consumption during the year 1886 was as follows: —

	Gallons.	Gallons per head per day.
Sudbury and Cochituate supply	26,627,900	74.3
Mystic supply	7,299,800	72.5
Total	34,027,700	73.9

The increase in consumption over that of the year 1885 was 4 per cent. on the Sudbury and Cochituate works, 9.8 per cent. on the Mystic works, and 5.2 per cent. on the combined supplies. These per centages are somewhat larger than the probable increase in the population of the city, especially on the Mystic works where the need of additional means of preventing waste is plainly shown.

I would recommend that the Deacon meters be used in Chelsea and Somerville, in order that the consumption may be kept within the safe capacity of the present Mystic works, until some additional source of supply can be obtained. The table on page 45 and the diagram facing same page show the daily average consumption for each month since the year 1875.

Detection of Waste.

The operation of the Deacon waste detection system and the work of setting stopcocks on the service-pipes throughout the city has been under the special charge of Assistant Dexter Brackett, who furnishes the following statement of the work: —

"City Engineer's Office,
"Boston, January 20, 1887.

"William Jackson, Esq., *City Engineer:* —

"Dear Sir,—The detection of waste by means of the Deacon meters and sidewalk stopcocks has been continued during the year. From April 1, until Nov. 27, a force of from 12 to 15 men was employed in operating the meters, and making night inspections by means of the Church and sidewalk stopcocks. The inspection of the 11,325 sidewalk stopcocks, which are now in use, resulted in the detection of 1,946 cases of waste. These were reported to the Waste Detection Department for examination with the following results: —

Service-pipes burst	235
Defective water-closets (of which 384 were of the Hopper pattern)	580
Defective faucets	518
" ballcocks	800
" stopcocks	12
Wilful or negligent waste	460

"The advantage of having the sidewalk stopcocks has been shown by the fact that in the sections of South Boston, where the stopcocks have been set during the past year, the waste has been largely reduced, although numerous house-to-house inspections had been previously made. The setting of these sidewalk cocks was commenced on April 6, and continued with some interruptions until October 22.

"950 Church stopcocks were set in the city proper, and 4,491 stopcocks of the ordinary pattern in South Boston.

"DEXTER BRACKETT,
"*Assistant Engineer.*"

Distribution.

A contract for pipes and special castings was made with R. D. Wood & Co., on January 9, 1886, at $29.40 per ton for both pipes and specials, and they have furnished 2,482 tons of pipe, and 104 tons of special castings.

The distributing mains of the Sudbury and Cochituate works have been extended 11.7 miles, and 2.4 miles of force, and supply mains have been laid for the new high-service works. Two and three-tenths miles of the old tuberculated pipes have been replaced with coated pipes of larger diameter. The distributing-mains of the Mystic works have been extended 10,606 feet, and 3,590 feet of the wrought-iron and cement pipe have been replaced by cast-iron pipes.

The raising of the 48-inch main in Beacon street, at the crossing of the Boston & Albany Railroad, has been successfully completed.

About 1,850 lineal feet of this supply main was raised and supported by a pile trestle in the manner shown on Plate 1.

At the bridge the pipe was raised about 18 feet, the amount of the raising diminishing to zero about 900 feet either way from that point. Piles were driven on each side of the pipe at intervals of 12 feet, and capped 6 inches below the raised grade of the street with double girder-caps. Between these bents of piles were driven intermediate bents, which were to be used to support the pipe when raised. The earth was then excavated around the pipe and the chains and lifting screws placed in position.

When these arrangements had been completed the pipe was cut on each side of the railroad bridge, and the entire length from the bridge to the foot of the grade raised at one operation, without breaking the joints. As soon as the pipe was raised to its new position the supporting caps were placed in position, and wedges driven between the pipe and the 12 × 12-inch caps. The pipe was then connected across the bridge, all of the joints redriven, and the water turned on. The bracing and timbers for the support of the railroad track were then placed in position, and the filling of the street is now being done. In order to avoid communicating to the water-pipe the jar caused by the running and dumping of gravel-trains on the trestle, the wedges between the pipe and the 6 × 12-inch girder-caps which were bolted to the piles carrying the railroad track, were not put in until the filling was raised above the top of the pipe.

The pipe was thus supported independently from the railroad trestle. The water passes over the railroad bridge in two wrought-iron pipes, 36 inches in diameter, connecting with the 48-inch pipe at each end by means of Y-branches.

The capacity of the pipes laid previous to the year 1868 has been greatly reduced by the formation of tubercles on their inner surfaces. These tubercles diminish the effective area of the pipes, and greatly increase the frictional resistance

to the flow of the water by roughening the inner surface of the pipes.

Experiments made in South and East Boston showed that 4-inch and 6-inch pipes, which had been laid about 35 years, would deliver but about one-fourth the quantity that a new pipe would furnish, and that many pipes of these sizes would not furnish an adequate supply for two steam fire-engines. In 1884 a number of trials were made in East Boston, of a machine, which had been used in Halifax, for removing the tuberculations from old pipes.

These trials were not satisfactory, although Mr. E. H. Keating, the City Engineer of Halifax, had used the machine there with success, generally, however, in pipes of larger size. In the fall of 1885 a single trial was made of a machine, invented by D. H. Sweeney, of Fitchburg, Mass., with successful result, and further trials were made in May, 1886. The results of these trials were so favorable that four of these machines were purchased, two for 6-inch and two for 12-inch pipe. Between August 18 and October 2, 17,000 feet of 6-inch pipe were cleaned in the East Boston District. The cost of this work was about 17 cents per lineal foot of pipe cleaned.

The machine consists of a flexible central shaft, composed of solid steel springs connecting small castings, to which are hinged steel scrapers arranged radially around the shaft.

Coiled springs keep the scrapers against the sides of the pipe, and yet admit of the scrapers turning back so as to pass taps, or other obstructions. Rubber pistons, just fitting the pipe, are attached to the shaft behind the scrapers, and the machine, having been introduced into the pipe, is forced through by the water-pressure acting on these pistons.

About 400 feet of the 16-inch main which supplied the town of Everett, was frozen on Malden bridge during severe cold and windy weather in the early part of March, and the greater portion of the town of Everett was without a supply for three days. This pipe furnished almost all of the town's supply, and it was supposed that there would be sufficient current to prevent freezing; in fact, no trouble had been experienced in the eleven years that the pipe had been used.

To prevent freezing in the future the pipe has been boxed during the past season. The pile-trestle and boxing of the 16-inch and 20-inch mains crossing the Mystic river at Chelsea bridge, should be repaired or rebuilt during the present year.

General Condition and Requirements of the Works.

The Sudbury and Cochituate works may be said to be generally in good condition. Some of the shallow portions of Lake Cochituate should be deepened and improved by the removal of mud and stumps, as has been done at the Sudbury-river reservoirs.

The building of a new dam at the outlet of Lake Cochituate has been recommended in previous reports. The signs of weakness discovered in the lower dam during the past year, and the need of a larger overflow, which was plainly shown during the freshet of February last, confirm my opinion that this work should not be longer delayed.

I would also renew my recommendation of last year that a portion of the Newton tunnel be lined with brick.

The condition of the Mystic supply is not satisfactory; the consumption from these works is increasing rapidly, and has already exceeded the safe capacity of the supply. Not only is the supply insufficient in quantity, but it is only by constant and careful attention that it can be kept comparatively pure, and it is certain to constantly deteriorate in quality.

The surveys and investigations necessary for obtaining an additional supply from the Shawshine river have been made during the year, and it is to be hoped that the requisite authority for the construction of the works may be obtained from the present Legislature, in order that the works may be completed as soon as possible. More work has been done during the past year, in improving the distribution system, than for several years past, both by relaying and cleaning the old tuberculated pipes. This work should be continued, and I would recommend that at least $25,000 be expended for this purpose during the coming season.

Appended to this report will be found the usual tables in regard to rainfall, consumption, yield of water-sheds, etc.

Respectfully submitted,

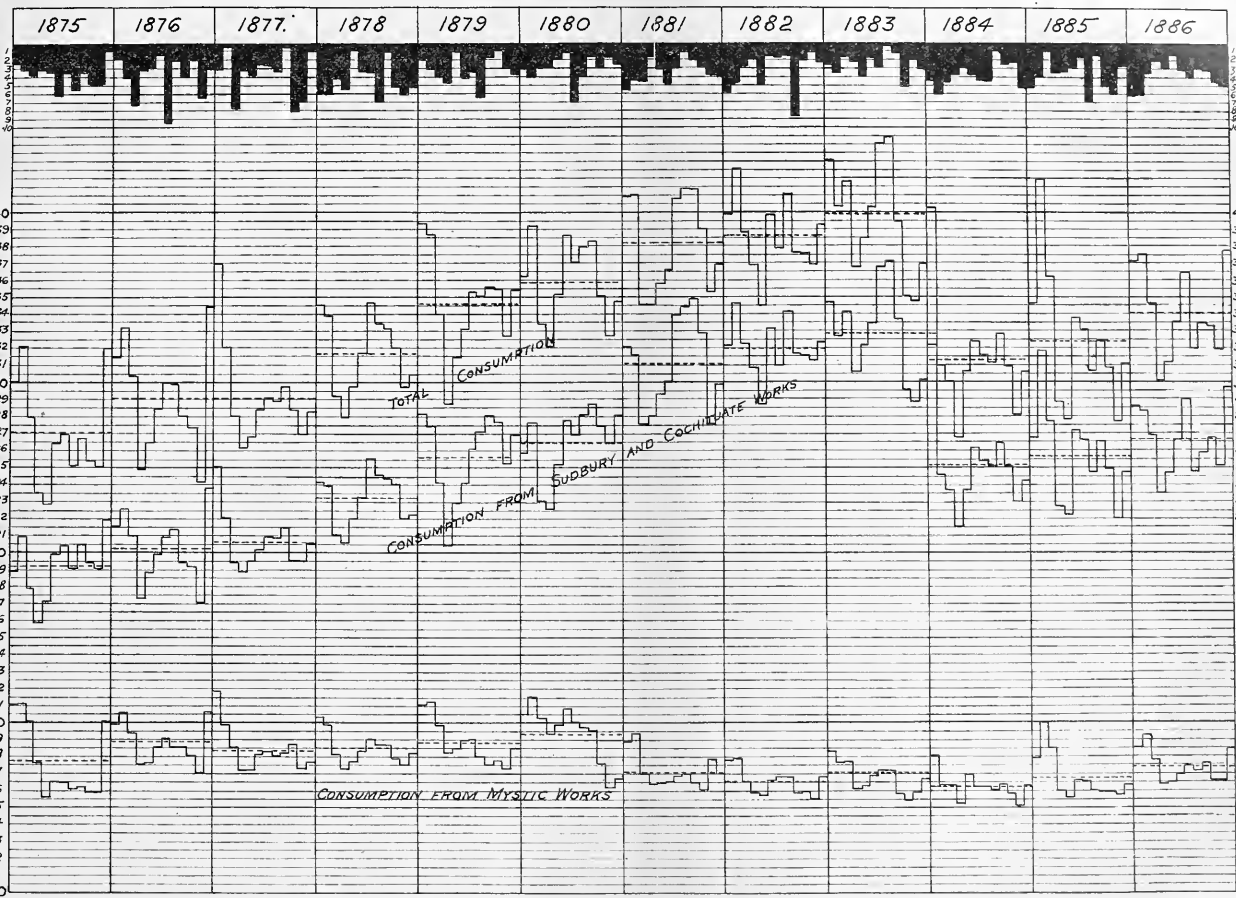
WILLIAM JACKSON,
City Engineer and Engineer B. W. Board.

BEACON STREET MAIN (48-INCH), AS RAISED ON TRESTLE.

BOSTON WATER WORKS.

Diagram showing the rainfall and daily average consumption for each month.

Yearly Averages shown thus -------



Daily Average Consumption of Water, in Gallons, from the Cochituate and Mystic Works.

	COCHITUATE WORKS.							MYSTIC WORKS.						
MONTHS.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1880.	1881.	1882.	1883.	1884.	1885.	1886.
January	25,817,600	32,121,900	32,151,100	34,715,500	32,162,300	26,711,900	28,561,900	10,511,279	8,756,500	7,816,200	8,369,600	8,019,100	7,855,400	8,510,300
February . . .	27,625,800	31,607,900	34,662,300	32,690,700	24,598,000	31,847,400	28,291,100	11,616,248	9,428,700	7,937,300	7,714,700	6,349,500	10,019,500	9,275,700
March	23,095,700	27,531,700	32,256,300	34,110,700	23,711,900	27,697,200	26,886,800	10,324,323	7,042,800	6,573,700	7,737,300	6,337,100	8,487,500	7,780,000
April	22,670,700	28,146,200	30,827,000	30,617,600	21,505,700	22,720,450	23,470,400	9,400,931	6,420,700	5,946,100	6,171,100	5,242,100	6,042,600	6,636,500
May	25,238,200	29,307,600	28,738,000	32,169,500	23,708,500	22,168,400	24,680,100	9,962,213	6,502,900	5,793,600	6,319,100	5,800,000	5,605,700	6,444,000
June	27,795,400	30,059,200	33,178,400	33,419,200	26,184,600	27,214,800	26,574,900	10,891,057	6,556,700	6,664,400	6,912,500	6,245,600	6,594,200	6,941,100
July	26,951,800	33,885,300	30,992,600	36,774,000	25,409,000	26,606,200	28,987,500	10,051,544	6,906,400	6,881,400	7,307,600	6,312,300	6,513,300	7,437,500
August	28,175,100	34,472,200	34,149,300	37,141,000	25,065,200	24,686,400	24,770,600	9,754,149	7,011,700	6,912,200	7,261,500	6,088,400	6,047,600	7,166,800
September . .	28,734,400	34,801,500	31,691,600	33,645,600	26,389,500	26,493,600	25,835,600	9,591,891	6,587,100	5,964,100	5,846,300	6,411,150	5,931,900	7,585,200
October	27,487,900	32,871,200	31,563,800	29,575,800	25,022,900	24,945,500	25,713,100	7,634,888	6,195,400	6,011,300	5,497,200	5,834,200	5,914,900	6,552,000
November . .	26,458,400	27,519,800	31,318,700	28,839,300	22,954,200	21,942,750	25,036,200	6,245,891	7,870,400	5,577,400	5,930,600	5,119,700	5,710,300	6,546,000
December . . .	28,010,500	29,860,400	32,352,800	30,174,200	24,234,800	24,724,900	29,706,800	6,778,046	7,056,900	6,877,600	6,771,500	6,330,800	6,356,700	8,043,500
Yearly average	26,500,000	31,020,200	31,970,800	32,836,900	25,090,500	25,607,200	26,627,900	9,387,879	7,194,700	6,574,400	6,819,200	6,209,700	6,737,350	7,399,800

Diversion of Sudbury-river Water, 1880-86.

Month.	1880.		1881.		1882.	1883.		1884.		1885.	1886.
	To Lake Cochituate.	To Chestnut-Hill Res'r.	To Lake Cochituate.	To Chestnut-Hill Res'r.	To Chestnut-Hill Res'r.	To Lake Cochituate.	To Chestnut-Hill Res'r.	To Lake Cochituate.	To Chestnut-Hill Res'r.	To Chestnut-Hill Res'r.	To Chestnut-Hill Res'r.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
January	228,400,000	673,600,000	.....	814,800,000	595,000,000	.....	733,400,000	.....	697,000,000	473,900,000	502,200,000
February	11,300,000	604,100,000	.....	680,300,000	975,700,000	.....	597,800,000	1,094,300,000	265,400,000	560,400,000	380,800,000
March	8,200,000	268,400,000	.....	853,600,000	1,002,300,000	17,200,000	634,700,000	.....	312,500,000	495,900,000	467,400,000
April	161,300,000	348,000,000	.....	810,700,000	781,200,000	967,900,000	535,700,000	.....	228,800,000	350,400,000	307,000,000
May	280,800,000	460,000,000	.....	960,100,000	502,800,000	260,000,000	613,800,000	.....	268,400,000	308,500,000	344,700,000
June	136,700,000	398,600,000	.....	941,700,000	491,800,000	.....	631,600,000	168,400,000	414,500,000	768,000,000	427,100,000
July	.....	378,400,000	.....	911,200,000	646,900,000	.....	754,300,000	152,000,000	430,100,000	434,600,000	534,500,000
August	.....	592,000,000	.....	730,700,000	655,800,000	.....	640,900,000	1,600,000	406,100,000	401,100,000	463,100,000
September	.....	445,500,000	.....	731,500,000	308,900,000	.....	467,100,000	.....	442,200,000	386,100,000	414,700,000
October	.....	434,600,000	.....	429,300,000	570,300,000	.....	483,300,000	.....	432,900,000	368,200,000	474,100,000
November	.....	398,200,000	.....	321,700,000	572,300,000	.....	580,800,000	.....	363,900,000	297,600,000	381,800,000
December	.....	402,100,000	187,600,000	472,100,000	632,200,000	.....	536,800,000	.....	432,500,000	379,900,0 0	570,200,000
Totals	826,700,000	5,403,500,000	187,600,000	8,657,700,000	7,735,200,000	1,245,100,000	7,209,900,000	1,416,300,000	4,694,300,000	5,224,700,000	5,267,600,000
Total diversion from Sudbury river	6,230,200,000		8,845,300,000		7,735,200,000	8,455,000,000		6,110,600,000		5,224,700,000	5,267,600,000
Average daily diversion for whole year	17,022,400		24,233,700		21,192,300	23,164,400		16,695,600		14,314,200	14,431,800

Statement showing amount of Water diverted from Sudbury River to Lake Cochituate and Chestnut-Hill Reservoir; Amount wasted; Amount of flow in River; Percentage of Rainfall collected, etc., 1875 to 1886.

(Water-shed from 1875 to 1878, inclusive, = 77.764 sq. miles; in 1879, = 78.238 sq. miles; and in 1880 to 1886, inclusive, = 76.305 sq. miles.)

YEAR.	Amount of Water diverted to Lake Cochituate and Chestnut-Hill Reservoir.	Amount of Water used by Framingham Water Co.	Amount of Water wasted from River.	STORAGE.		Total amount of flow in River.	Daily average amount of flow in River.	Rainfall.	Rainfall collected.	Percentage of Rainfall collected.
				Gain.	Loss.					
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Inches.*	*Inches.*	*Per cent.*
1875 . . .	2,555,800,000	. . . . .	24,971,600,000	66,300,000	. . . . .	27,593,700,000	75,599,200	45.490	20.418	44.88
1876 . . .	2,528,300,000	. . . . .	29,942,300,000	. . . . .	160,700,000	32,309,900,000	88,278,400	49.563	23.908	48.24
1877 . . .	1,894,350,000	. . . . .	32,438,300,000	112,100,000	. . . . .	34,444,750,000	94,369,200	44.018	25.487	57.90
1878 . . .	3,422,100,000	. . . . .	37,125,200,000	654,700,000	. . . . .	41,202,000,000	112,882,200	57.931	30.487	52.63
1879 . . .	3,749,200,000	. . . . .	20,817,500,000	962,200,000	. . . . .	25,528,900,000	69,942,200	41.419	18.775	45.33
1880 . . .	6,230,200,000	. . . . .	11,290,000,000	. . . . .	958,600,000	16,561,600,000	42,250,300	38.177	12.487	32.71
1881 . . .	8,845,360,000	. . . . .	17,279,000,000	751,700,000	. . . . .	26,876,000,000	73,633,900	44.169	20.257	45.88
1882 . . .	7,735,200,000	. . . . .	16,273,900,000	. . . . .	352,600,000	23,656,500,000	64,812,300	39.394	17.841	45.29
1883 . . .	8,455,000,000	. . . . .	7,251,900,000	. . . . .	1,086,400,000	14,620,500,000	40,056,200	32.780	11.023	33.63
1884 . . .	6,110,600,000	. . . . .	23,228,900,000	1,744,600,000	. . . . .	31,084,100,000	84,926,200	47.135	23.440	49.73
1885 . . .	5,224,700,000	61,800,000	19,878,800,000	. . . . .	446,900,000	24,718,400,000	67,721,600	43.545	18.637	42.80
1886 . . .	5,267,700,000	76,600,000	23,023,000,000	1,464,500,000	. . . . .	29,831,700,000	81,730,700	46.065	22.498	48.84
Averages,	5,168,195,300	69,200,000	21,960,033,300	. . . . .	. . . . .	27,369,004,200	74,683,800	44.140	20.438	45.65

Statement showing Amount of Water drawn from Lake Cochituate; Amount wasted; Amount of Rainfall collected in Lake; Amount received into Lake from Sudbury River; Percentage of Rainfall collected, etc., 1852 to 1886; Water-shed of Lake, 12,077 acres.

YEAR.	Amount of Water drawn from Lake.	Amount of Water wasted from Lake.	Amount received into Lake from Sudbury River.	STORAGE.		Total amount of Rainfall collected in Lake.	Daily average amount of Rainfall collected in Lake.	Rainfall.	Rainfall collected.	Percentage of Rainfall collected.
				Gain.	Lost.					
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Inches.*	*Inches.*	*Per cent.*
1852[1]	2,974,042,800	4,020,566,900	.....	.....	261,360,000	6,733,249,700	18,396,900	47.93	20.61	43.
1853	3,117,939,500	3,166,417,500	.....	239,580,000	.....	6,523,937,000	17,873,800	55.73	19.51	35.
1854	3,614,230,000	4,187,733,000	.....	.....	217,800,000	7,584,163,000	20,778,500	43.15	22.87	53.
1855	3,776,399,500	No account kept	.....	.....	326,700,000	.....	.....	34.96	.....	.....
1856	4,409,787,600	"	.....	598,950,000	.....	.....	.....	40.80	.....	.....
1857	4,644,990,000	10,625,900,000	.....	32,670,000	.....	15,303,560,000	41,927,600	63.10	46.69	74.
1858	4,689,155,000	1,934,560,000	.....	.....	141,570,000	6,482,085,000	17,759,000	48.66	19.46	40.
1859[2]	4,808,875,000	7,569,000,000	.....	283,140,000	.....	12,661,015,000	34,687,700	49.02	38.24	78.
1860	6,309,108,000	None.	.....	174,240,000	.....	6,483,348,000	17,714,100	55.44	19.40	35.
1861	6,639,095,900	3,377,559,000	.....	.....	1,459,260,000	8,557,394,900	23,444,900	45.44	25.45	56.
1862	6,059,000,000	33,200,000	.....	1,306,800,000	.....	7,399,000,000	20,271,200	49.69	22.36	45.
1863	5,927,052,500	2,165,696,500	.....	762,300,000	.....	8,855,049,000	24,260,400	69.30	26.88	39.
1864	6,705,306,700	1,368,746,000	.....	.....	1,848,577,000	5,625,475,700	15,370,200	42.60	18.35	43.
1865	4,621,630,000	1,688,120,700	.....	743,242,500	.....	7,052,993,200	19,323,300	49.46	20.50	41.
1866	4,463,585,000	None.	.....	743,242,500	.....	5,206,827,500	14,265,300	62.32	16.01	26.

1867	4,951,225,000	2,482,041,000	. . . . .	. . . . .	698,811,000	6,734,455,000	18,450,600	56.25	21.80	39.
1868	5,405,515,000	2,507,684,000	. . . . .	346,371,000	. . . . .	8,259,570,000	22,567,200	49.71	24.98	50.
1869	5,503,751,000	1,635,570,000	. . . . .	480,882,000	. . . . .	7,620,203,000	20,877,300	64.34	21.99	34.
1870	5,477,810,000	4,818,971,000	. . . . .	. . . . .	1,736,085,000	8,560,696,000	23,453,900	55.89	26 08	47.
1871	5,223,500,000	None.	. . . . .	. . . . .	250,933,000	4,972,567,000	13,623,500	45.39	15.16	33.
1872	5,775,151,200	None.	1,676,666,400	1,543,995,500	. . . . .	5,642,480,300	15,416,600	48.47	17.22	35.
1873	6,511,826,900	2,917,977,000	. . . . .	. . . . .	515,132,000	8,914,671,900	24,423,800	45.43	27.13	60.
1874	6,623,972,900	1,145,851,700	. . . . .	. . . . .	1,367,715,000	6,402,109,600	17,540,000	35.93	19.52	54.
1875	7,092,955,500	None.	2,555,800,000	1,222,885,000	. . . . .	5.760,040,500	15,780,900	45.49	17.57	39.
1876	7,277,175,200	1,619,243,800	2,528,300,000	43,438,000	. . . . .	6,411,557,000	17,517,900	48.49	19.54	40.
1877	7,626,889,200	1,484,978,600	1,894,350,000	378,727,000	. . . . .	7,596,244,800	20,811,600	43.80	23.17	53.
1878	7,743,904,700	3,341,875,000	2,668,300,000	219,789,000	. . . . .	8,637,268,700	23,663,700	53.58	26.34	49.
1879	6,051,838,900	1,523,361,400	411,300,000	. . . . .	1,322,697,300	5,841,203,000	16,003,300	38.01	17.81	47.
1880	4,284,147,100	65,577,700	826,700,000	. . . . .	146,265,000	3,376,759,800	9,226,100	35.83	10.30	29.
1881	2,846,459,700	2,231,016,700	187,600,000	468,089,400	. . . . .	5,357,965,800	14,679,400	41.09	16.34	40.
1882	3,935,490,600	1,358,543,700	. . . . .	. . . . .	357,334,700	4,936,699,600	13,525,200	40.29	15.05	37.
1883	4,731,227,700	162,361,800	1,245,100,000	. . . . .	334,400,000	3,314,089,500	9,079,700	31.20	10.11	32.
1884	4,533,156,450	1,842,837,100	1,416,300,000	1,340,436,700	. . . . .	6,300,130,250	17,213,450	45.57	19.21	42.
1885	4,091,674,900	1,006,622,800	. . . . .	8,594,800	. . . . .	5,106,892,500	13,991,500	43.66	15.57	36.
1886	4,432,536,100	3,116,283,200	. . . . .	. . . . .	360,662,000	7,188,157,300	19,693,600	46.97	21.92	47.
Averages . . .	5,208,011,600	2,224,189,000	. . . . .	. . . . .	. . . . .	7,012,177,600	19,200,400	47.80	21.31	44.

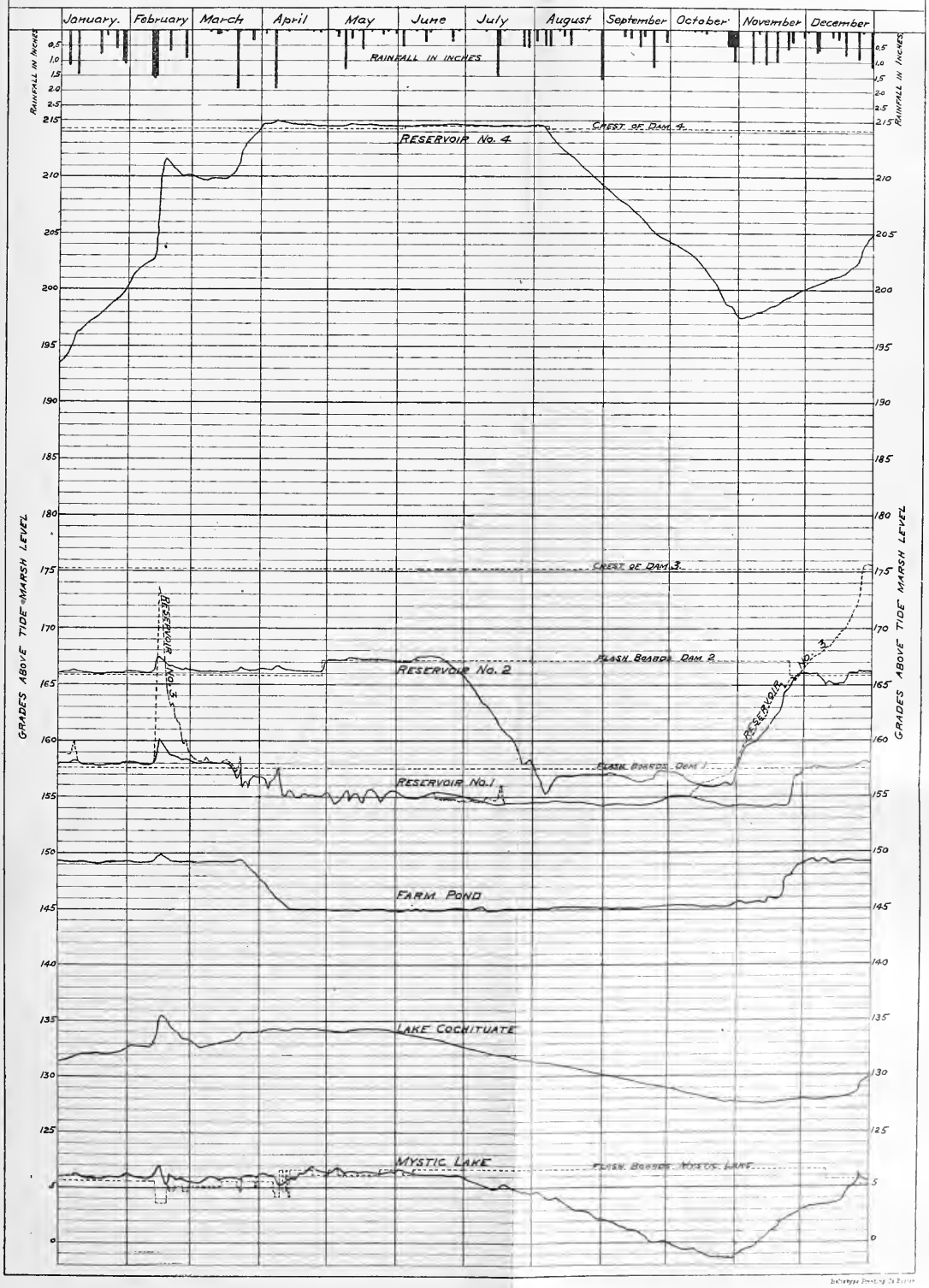
[1] Observation of Rainfall at Lake Cochituate commenced 1852, and these observations are assumed as correct for the whole district.
[2] Lake raised two feet.

Table showing the average Monthly and Yearly Heights above tide-marsh level of the Water in the Lakes and Reservoirs of the Boston Water-Works.

MONTHS.	Reservoir No. 1. Flash-boards 159.29.		Reservoir No. 2. Flash-boards 167.12.		Reservoir No. 3. Stone-crest. 175.24.		Reservoir No. 4. Stone-crest 214.21.	Farm Pond. High water 149.25		Lake Cochituate. High water 134.36.		Chestnut-Hill Reservoir. High water 124.00.		Brookline Reservoir. High water 124.00.		Parker-Hill Reservoir. High water 219.00.		Mystic Lake. High water 7.00.		Mystic Reservoir. High water 147.00.	
	1885.	1886.	1885.	1886.	1885.	1886.	1886.	1885.	1886.	1885.	1886.	1885.	1886.	1885.	1886.	1885.	1886.	1885.	1886.	1885.	1886.
January .	157.80	157.96	166.10	166.09	175.55	158.24	197.41	146.81	149.22	132.32	132.07	123.71	123.75	123.33	123.49	217.63	217.90	6.44	6.03	146.99	146.89
February .	157.74	158.46	166.12	166.43	175.43	161.34	206.73	146.96	149.35	132.89	133.63	123.44	123.57	123.19	123.33	217.15	217.46	6.10	5.98	146.93	146.86
March . .	158.00	157.42	166.20	166.24	175.45	157.70	211.06	146.95	149.08	132.58	133.40	123.47	123.59	123.27	123.37	217.25	217.54	5.97	5.94	146.89	146.85
April . . .	158.20	155.54	166.42	166.33	175.53	155.73	214.65	145.12	145.60	133.85	134.29	123.84	123.80	123.43	123.63	217.72	218.17	6.34	6.13	146.77	146.67
May . . .	159.57	155.09	167.38	167.24	175.52	155.16	214.53	145.14	145.01	134.31	134.22	123.55	123.66	123.37	123.46	217.80	218.30	6.61	6.46	146.73	146.73
June . . .	159.29	155.16	165.54	167.02	174.88	154.96	214.55	145.24	145.00	134.29	133.35	123.36	123.72	123.16	123.07	217.65	218.18	6.35	6.20	146.73	146.74
July . . .	158.42	154.49	160.32	161.33	173.32	154.63	214.56	145.04	145.06	133.48	131.97	123.64	123.72	123.42	123.47	217.68	218.03	5.93	5.04	146.79	146.80
August . .	158.11	154.48	156.93	156.72	173.62	154.54	211.97	145.14	145.21	132.08	130.85	123.77	123.85	123.56	123.45	218.12	217.88	5.77	3.34	146.74	146.79
September .	157.90	154.41	155.89	156.84	173.35	154.46	206.61	145.04	145.21	130.71	129.51	123.79	123.64	123.58	123.31	217.30	217.92	5.88	0.94	146.67	146.80
October . .	157.89	154.63	159.78	156.31	173.92	156.09	201.32	145.05	145.29	129.49	128.15	123.71	123.60	123.50	123.35	217.93	218.13	5.89	—0.92	147.00	146.65
November .	158.28	154.69	165.78	162.21	175.51	163.14	198.61	145.04	146.61	129.58	127.63	123.94	123.65	123.75	123.40	218.15	217.75	6.51	0.96	147.04	146.71
December .	158.01	157.70	166.06	165.72	170.47	170.41	201.75	148.42	149.22	131.04	128.28	123.80	123.71	123.32	122.96	217.58	218.32	6.26	4.17	146.87	146.85
Yearly ave.	158.27	155.83	163.54	163.21	174.38	158.04	207.81	145.83	146.65	132.22	131.45	123.67	123.69	123.41	123.36	217.66	217.96	6.17	4.19	146.85	146.78

BOSTON WATER WORKS.

Diagram showing the heights of Sudbury River Reservoirs, Farm Pond, and Cochituate and Mystic Lakes, and the Rainfall on the Sudbury River Water Shed during the year 1886.



Statement showing Amount of Water drawn from Mystic Lake; Amount wasted; Amount of Rainfall collected in Lake; Percentage of Rainfall collected, etc., 1876–1886; Water-shed of Lake, 17,200 Acres.

YEAR.	Amount of Water drawn from Lake.	Amount of Water wasted from Lake.	STORAGE.		Total amount of Rainfall collected in Lake.	Daily average amount of Rainfall collected in Lake.	Rainfall.	Rainfall collected.	Percentage of Rainfall collected.
			Gain.	Loss.					
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Inches.*	*Inches.*	*Per cent.*
1876	3,230,101,300	6,369,774,700	. . . . .	32,583,000	9,567,293,000	26,140,100	47.00	20.49	43.6
1877	3,069,554,800	7,250,223,500	. . . . .	16,291,400	10,303,486,900	28,228,700	43.095	22.06	51.2
1878	3,367,490,400	8,718,547,600	. . . . .	26,000,000	12,060,038,000	33,041,200	54.065	25.82	47.8
1879	3,490,848,200	4,625,091,800	. . . . .	203,000,000	7,913,540,000	21,680,900	35.30	16.94	48.0
1880	3,692,195,700	2,158,761,200	. . . . .	113,500,000	5,703,756,900	15,584,000	34.42	12.21	35.5
1881	2,815,579,900	5,534,300,000	371,200,000	. . . . .	8,721,079,900	23,893,400	41.91	18.67	44.5
1882	2,570,896,700	4,444,668,000	15,000,000	. . . . .	7,030,564,700	19,261,800	39.165	15.05	38.4
1883	2,664,514,000	2,034,702,600	. . . . .	347,579,000	4,351,637,800	11,922,300	31.22	9.32	29.84
1884	2,469,761,000	6,574,003,800	380,600,000	. . . . .	9,424,364,800	25,749,600	44.39	20.18	45.46
1885	2,639,278,800	5,588,860,500	. . . . .	33,200,000	8,194,939,300	22,451,900	44.50	17.55	39.43
1886	2,700,937,400	7,743,258,900	. . . . .	28,400,000	10,415,796,300	28,536,400	45.56	22.30	48.95
Averages	2,973,741,700	5,549,344,800	. . . . .	. . . . .	8,516,954,300	23,317,300	41.875	18.24	42.97

Statement of Operations at the Mystic-Pumping Station, for the Year 1886.

1886.	Engine No. 1.			Engine No. 2.			Engine No. 3.			Total amount pumped.	Daily average amount pumped.	Daily average amount coal consumed.	Daily average amount clinkers and ashes.	Per cent. ashes and clinkers.	Quantity pumped per lb. of coal.	Average lift in ft.	Duty in ft.-lbs. per 100 lbs. of total coal.
	Total pumping time.		Amount pumped.	Total pumping time.		Amount pumped.	Total pumping time.		Amount pumped.								
Month.	*Hrs.*	*Min.*	*Gallons.*	*Hrs.*	*Min.*	*Gallons.*	*Hrs.*	*Min.*	*Gallons.*	*Gallons.*	*Gallons.*	*Lbs.*	*Lbs.*	*Per ct.*	*Gal.*	*Ft.*	*Ft.-lbs.*
January	. . .	. . .	. . . . .	274	15	54,360,000	665	45	209,356,800	263,716,800	8,507,000	19,548	1,712	8.8	435.2	148.63	53,943,300
February	9	45	1,842,200	192	. . .	39,365,700	671	. . .	218,265,600	259,473,500	9,266,900	20,857	1,809	8.7	444.3	148.42	54,997,000
March	84	45	15,266,100	32	30	6,281,600	681	30	219,776,000	241,323,700	7,784,600	18,048	1,994	11.0	431.3	148.77	53,515,700
April	. . .	. . .	. . . . .	. . .	. . .	. . . . .	635	. . .	199,065,600	199,065,600	6,635,500	14,900	1,297	8.7	445.3	148.51	55,158,300
May	. . .	. . .	. . . . .	. . .	. . .	. . . . .	712	. . .	199,705,600	199,705,600	6,442,100	13,742	1,180	8.6	468.8	148.14	57,918,700
June	. . .	. . .	. . . . .	7	15	1,449,600	693	30	206,796,800	208,246,400	6,941,500	14,450	1,197	8.3	480.4	148.24	59,390,900
July	. . .	. . .	. . . . .	. . .	. . .	. . . . .	738	15	229,939,200	229,939,200	7,417,400	15,339	1,333	8.7	483.6	149.03	60,103,800
August	. . .	. . .	. . . . .	28	30	5,496,400	728	45	217,139,200	222,635,600	7,181,800	14,694	1,234	8.4	488.8	149.07	60,766,300
September	. . .	. . .	. . . . .	140	45	25,836,100	686	15	202,009,600	227,845,700	7,594,900	15,933	1,412	8.9	476.7	149.58	59,464,300
October	. . .	. . .	. . . . .	37	. . .	7,489,600	664	30	195,302,400	202,792,000	6,541,700	14,387	1,236	8.6	454.7	149.86	56,828,700
November	18	45	3,231,400	2	20	498,300	695	45	192,998,400	196,728,100	6,557,600	14,010	1,175	8.4	468.1	149.06	58,188,100
December	41	45	7,217,800	125	. . .	23,208,700	711	. . .	218,777,600	249,204,100	8,038,800	17,361	1,456	8.4	463.0	148.59	57,380,900
Totals and Averages.	155	. . .	27,557,500	839	35	163,986,000	8,283	15	2,509,132,800	2,700,676,300	7,399,100	16,081	1,418	8.8	460.1	148.82	57,108,200

Statement of Operations at the Highland Pumping-Station for the Year 1886.

1886.	Worthington Engine.			Engine No. 2.			Total amount pumped.	Daily average amount pumped.	Total amount of coal consumed.	Daily average amount coal consumed.	Total amount ashes and clinkers.	Per cent. ashes and clinkers.	Quantity pumped per lb. of coal.	Average lift in feet.	Duty in ft.-lbs. per 100 lbs. of total coal.
	Total pumping time.		Amount pumped.	Total pumping time.		Amount pumped.									
	Hrs.	*Min.*	*Gallons.*	*Hrs.*	*Min.*	*Gallons.*	*Gallons.*	*Gallons.*	*Lbs.*	*Lbs.*	*Lbs.*	*Per cent.*	*Gals.*	*Feet.*	*Ft.-lbs.*
January	657	...	87,513,000	...	...	.....	87,513,000	2,823,000	160,700	5,184	21,655	13.5	544.6	111.80	50,778,500
February	600	15	82,816,500	...	...	.....	82,816,500	2,957,700	152,200	5,436	19,810	13.0	544.1	112.27	50,946,800
March	662	30	86,831,000	...	...	.....	86,831,000	2,801,000	164,400	5,303	24,150	14.7	528.2	110.65	48,740,100
April	630	...	75,748,500	...	...	.....	75,748,500	2,524,950	138,300	4,610	23,845	17.2	547.7	108.11	49,382,800
May	650	...	81,251,000	...	...	.....	81,251,000	2,621,000	146,100	4,713	24,380	16.7	556.1	108.34	50,249,200
June	628	...	86,226,500	...	...	.....	86,226,500	2,874,200	156,700	5,223	23,051	14.7	550.3	109.96	50,461,100
July	660	...	100,052,500	...	...	.....	100,052,500	3,227,500	175,800	5,671	24,660	14.0	569.1	112.04	53,177,600
August	643	10	87,621,500	...	...	.....	87,621,500	2,826,700	152,100	4,906	21,780	14.3	576.1	109.96	52,828,300
September	610	...	86,288,500	...	...	.....	86,288,500	2,876,300	151,000	5,033	21,740	14.4	571.4	111.80	53,284,300
October	651	...	89,404,000	...	...	.....	89,404,000	2,884,000	163,500	5,274	25,545	15.6	546.8	110.42	50,355,300
November	636	30	90,458,000	85	...	4,784,600	95,242,600	3,174,800	191,600	6,387	29,265	15.3	497.1	115.04	47,691,700
December	675	...	100,905,000	83	...	5,320,400	106,225,400	3,426,600	228,800	7,381	34,900	15.2	464.3	119.43	46,242,500
Totals and Averages	7,703	25	1,055,116,000	168	...	10,105,000	1,065,221,000	2,918,400	1,981,200	5,428	294,781	14.9	537.7	111.65	50,065,200

Rainfall in inches and hundredths on the Sudbury-River Water-shed for the Year 1886.

1886.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.375	. . .	. . .	. . .	0.05
3	. . .	. . .	. . .	0.12	. . .	0.535	. . .	. . .	. . .	. . .	. . .	. . .
4	. . .	0.01	. . .	. . .	0.03	. . .	. . .	. . .	. . .	. . .	. . .	. . .
5	1.165	. . .	. . .	. . .	0.215	. . .	. . .	. . .	. . .	. . .	. . .	. . .
6	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.50	. . .	. . .	. . .	0.725
7	. . .	. . .	. . .	1.925	. . .	. . .	. . .	. . .	. . .	. . .	1.10	0.655
8	. . .	. . .	. . .	. . .	1.30	. . .	. . .	0.755	. . .	. . .	. . .	. . .
9	1.45	. . .	0.075	. . .	. . .	0.03	. . .	. . .	. . .	. . .	. . .	. . .
10	. . .	. . .	. . .	. . .	. . .	. . .	0.035	. . .	0.23	. . .	0.13	. . .
11	. . .	. . .	. . .	. . .	0.305	. . .	. . .	. . .	. . .	. . .	. . .	. . .
12	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.045	. . .	0.05	. . .	. . .
13	. . .	4.635	0.26	0.05	. . .	0.405	. . .	. . .	0.25	. . .	1.13	0.215
14	. . .	. . .	. . .	. . .	0.03	. . .	. . .	0.225	. . .	. . .	. . .	. . .
15	. . .	0.01	. . .	. . .	. . .	0.085	. . .	. . .	. . .	0.055	. . .	. . .
16	. . .	. . .	0.04	. . .	0.665	. . .	2.05	. . .	. . .	. . .	. . .	0.30
17	0.01	. . .	. . .	. . .	. . .	. . .	. . .	0.495	0.54	0.11	1.065	. . .
18	. . .	. . .	. . .	. . .	. . .	. . .	0.01	. . .	. . .	. . .	. . .	0.825
19	0.815	0.68	. . .	. . .	. . .	. . .	. . .	. . .	0.215	. . .	. . .	. . .
20	. . .	. . .	. . .	. . .	0.075	. . .	. . .	. . .	. . .	. . .	. . .	. . .
21	. . .	. . .	1.945	. . .	. . .	. . .	. . .	. . .	. . .	0.015	. . .	. . .
22	0.205	. . .	0.065	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.595	. . .
23	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.245	. . .	. . .	. . .
24	. . .	. . .	. . .	0.045	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
25	. . .	. . .	. . .	. . .	0.17	0.395	. . .	0.035	. . .	. . .	0.395	0.96
26	0.615	0.945	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
27	. . .	. . .	. . .	0.085	0.065	. . .	0.56	. . .	. . .	. . .	. . .	0.05
28	. . .	. . .	0.35	. . .	. . .	0.015	. . .	. . .	. . .	. . .	. . .	. . .
29	. . .	. . .	. . .	. . .	. . .	. . .	0.58	. . .	0.425	. . .	. . .	. . .
30	2.105	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.23	. . .
31	. . .	. . .	0.875	. . .	0.145	. . .	0.03	1.67	. . .	3.005	. . .	1.195
Totals .	6.365	6.28	3.61	2.225	2.995	1.465	3.265	4.10	2.905	3.235	4.645	4.975

Total rainfall during the year, 46.065 inches.
Being an average of two gauges located at Framingham and Westboro'.

Rainfall in inches and hundredths on Lake Cochituate Water-shed for 1886.

1886.	January.	February	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.04
2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.33	. . .	. . .	. . .	. . .
3	. . .	. . .	. . .	0.10	. . .	0.53	. . .	. . .	. . .	. . .	. . .	. . .
4	. . .	0.03	. . .	. . .	0.03	. . .	. . .	. . .	. . .	. . .	. . .	. . .
5	1.00	. . .	. . .	. . .	0.22	. . .	. . .	. . .	. . .	. . .	. . .	. . .
6	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.50	. . .	. . .	. . .	0.96
7	. . .	. . .	. . .	1.68	. . .	. . .	. . .	. . .	. . .	. . .	1.34	0.81
8	. . .	. . .	. . .	. . .	1.31	. . .	. . .	1.05	. . .	. . .	. . .	. . .
9	1.45	. . .	0.07	. . .	. . .	0.04	. . .	. . .	. . .	. . .	. . .	. . .
10	. . .	. . .	. . .	. . .	. . .	. . .	0.06	. . .	0.43	. . .	0.12	. . .
11	. . .	. . .	. . .	. . .	0.29	. . .	. . .	. . .	0.17	. . .	. . .	. . .
12	. . .	. . .	0.04	. . .	. . .	. . .	. . .	0.31	. . .	0.07	. . .	. . .
13	. . .	4.95	0.18	0.06	. . .	0.36	. . .	. . .	0.22	. . .	1.12	0.17
14	. . .	. . .	. . .	. . .	0.04	. . .	. . .	0.10	. . .	. . .	. . .	. . .
15	. . .	0.02	. . .	. . .	. . .	0.10	1.54	. . .	. . .	0.02	. . .	. . .
16	. . .	. . .	0.04	. . .	0.64	0.01	0.09	. . .	0.27	. . .	. . .	0.46
17	0.03	. . .	. . .	0.01	. . .	0.01	. . .	0.54	0.20	0.07	. . .	. . .
18	. . .	. . .	. . .	. . .	. . .	. . .	0.02	. . .	. . .	. . .	1.02	0.94
19	0.79	0.71	. . .	. . .	. . .	. . .	. . .	. . .	0.11	. . .	. . .	. . .
20	. . .	. . .	. . .	. . .	0.09	. . .	. . .	. . .	. . .	. . .	. . .	. . .
21	. . .	. . .	1.94	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. .	. . .
22	0.17	. . .	0.05	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
23	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.30	. . .	0.54	. . .
24	. .	. . .	. . .	0.04	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
25	0.50	. . .	. . .	. . .	0.22	0.11	. . .	0.02	. . .	. . .	0.45	1.14
26	. . .	1.15	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
27	. . .	. . .	. . .	0.11	0.07	. . .	0.55	. . .	. . .	. . .	. . .	0.04
28	. . .	. . .	0.36	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
29	1.93	. . .	. . .	. . .	. . .	. . .	0.41	. . .	0.50	. . .	. . .	. . .
30	0.64	. . .	. . .	. . .	. . .	. . .	. . .	0.08	. . .	. . .	0.17	. . .
31	0.02	. . .	0.78	. . .	0.06	. . .	0.03	0.82	. . .	3.00	. . .	1.21
Totals	6.53	6.86	3.46	2.00	2.97	1.21	3.30	3.75	3.20	3.16	4.76	5.77

Total rainfall during the year, 46.97 inches.

Rainfall in inches and hundredths on the Mystic Lake Water-shed for 1886.

1886.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
2	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.595	. . .	. . .	. . .	0.01
3	0.01	. . .	. . .	0.01	. . .	0.67	. . .	. . .	. . .	. . .	. . .	. . .
4	. . .	. . .	. . .	. . .	0.025	. . .	. . .	. . .	. . .	. . .	. . .	. . .
5	1.135	. . .	. . .	. . .	0.24	. . .	. . .	. . .	. . .	. . .	. . .	. . .
6	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.26	. . .	. . .	. . .	0.86
7	. . .	. . .	. . .	1.965	. . .	. . .	. . .	. . .	. . .	. . .	0.93	0.325
8	. . .	. . .	. . .	. . .	1.24	. . .	. . .	1.12	. . .	. . .	. . .	. . .
9	1.49	. . .	0.08	. . .	. . .	0.01	. . .	. . .	. . .	. . .	. . .	. . .
10	. . .	. . .	. . .	. . .	. . .	. . .	0.03	. . .	0.265	. . .	0.155	. . .
11	. . .	. . .	. . .	. . .	0.23	. . .	. . .	. . .	. . .	. . .	. . .	. . .
12	. . .	. . .	0.04	. . .	. . .	. . .	. . .	. . .	. . .	0.005	. . .	. . .
13	. . .	5.545	0.245	0.095	. . .	0.495	. . .	. . .	0.355	. . .	0.995	0.18
14	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.06	. . .	. . .	. . .	. . .
15	. . .	. . .	. . .	. . .	. . .	0.01	2.05	. . .	. . .	0.06	. . .	. . .
16	. . .	. . .	0.03	. . .	0.775	. . .	0.57	. . .	0.31	. . .	. . .	0.155
17	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.46	0.165	0.035	. . .	. . .
18	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.805	1.105
19	0.835	0.675	. . .	. . .	. . .	. . .	. . .	. . .	0.075	. . .	. . .	. . .
20	. . .	. . .	. . .	. . .	0.085	. . .	. . .	. . .	. . .	. . .	. . .	. . .
21	. . .	. . .	2.185	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
22	0.235	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
23	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	1.305	. . .	0.635	. . .
24	. . .	. . .	. . .	0.015	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .
25	. . .	. . .	. . .	. . .	0.25	0.335	. . .	. . .	. . .	. . .	0.39	1.29
26	0.33	0.955	. . .	. . .	. . .	. . .	. . .	. . .	. . .	0.40	. . .	. . .
27	0.30	. . .	. . .	0.015	0.09	. . .	0.94	. . .	. . .	0.60	. . .	0.02
28	1.14	. . .	0.295	. . .	. . .	0.02	. . .	. . .	. . .	0.28	. . .	. . .
29	0.52	. . .	. . .	. . .	. . .	. . .	0.12	. . .	0.48	0.22	. . .	. . .
30	0.32	. . .	. . .	. . .	. . .	. . .	. . .	0.20	. . .	1.25	0.155	. . .
31	. . .	. . .	0.965	. . .	0.01	. . .	. . .	0.545	. . .	. . .	. . .	0.088
Totals .	6.315	7.175	3.84	2.10	2.945	1.54	3.71	3.24	2.955	2.85	4.065	4.825

Total rainfall during the year, 45.56 inches.
Being an average of two gauges located at Mystic Lake and Mystic Station.

Monthly Rainfall, in inches, for 1886, at various places in Massachusetts.

PLACE.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals.
Lake Cochituate	6.53	6.86	3.46	2.00	2.97	1.21	3.30	3.75	3.20	3.16	4.76	5.77	46.97
Framingham	6.54	6.28	3.59	2.05	2.98	1.30	3.15	3.79	3.05	3.49	4.47	5.17	45.86
Westboro'	6.19	6.28	3.63	2.40	3.01	1.63	3.38	4.41	2.76	2.98	4.82	4.78	46.27
Chestnut Hill	7.17	7.89	3.55	2.71	3.41	1.38	2.59	3.52	3.03	3.21	4.03	5.82	48.31
Mystic Station	6.40	7.15	3.72	1.91	2.76	1.56	3.70	3.48	3.04	2.72	4.06	4.97	45.47
Mystic Lake	6.23	7.20	3.96	2.29	3.13	1.52	3.72	3.00	2.87	2.98	4.07	4.68	45.65
Mystic Engine-house	6.605	6.51	3.275	1.47	2.68	1.48	4.01	2.615	2.81	2.58	3.89	4.825	42.75
Boston Pipe-yard	7.04	7.38	3.76	2.52	3.96	1.30	2.09	3.98	2.94	3.06	3.73	4.71	46.47
Boston (U.S. Signal Service)	7.08	7.04	3.20	1.70	3.08	1.34	1.81	3.64	2.73	3.27	3.81	3.44	42.14
Cambridge Observatory	7.36	7.82	3.53	2.07	3.21	1.44	3.23	2.81	3.45	2.72	3.91	5.05	46.60
Waltham (Boston Manufacturing Co.)	7.12	7.84	3.57	2.51	3.18	1.29	3.03	2.78	2.96	2.78	4.28	6.25	47.59
Lowell (Locks & Canals Co.)	6.765	6.535	3.388	1.966	3.587	1.859	3.512	3.128	3.963	2.781	4.901	4.444	46.829
Lowell (Merrimac Manufacturing Co.)	5.88	6.26	3.26	1.56	3.26	2.46	3.79	3.02	3.92	2.64	5.10	4.94	46.09
Averages	6.69	7.00	3.53	2.09	3.17	1.52	3.18	3.38	3.13	2.95	4.29	4.99	45.92

Rainfall Received and Collected — 1886.

MONTHS.	MYSTIC.			COCHITUATE.			SUDBURY.		
	Rainfall.	Rainfall Collected.	Per cent. Collected.	Rainfall.	Rainfall Collected.	Per cent. Collected.	Rainfall.	Rainfall Collected.	Per cent. Collected.
	Inches.	Inches.	Per cent.	Inches.	Inches.	Per cent.	Inches.	Inches.	Per cent.
January . .	6.315	2.27	36.03	6.53	2.28	34.96	6.365	2.568	40.35
February .	7.175	7.67	106.86	6.86	7.93	115.60	6.28	7.623	121.38
March . . .	3.84	3.88	101.02	3.46	3.51	101.50	3.61	3.619	100.24
April . . .	2.10	3.21	153.05	2.00	2.52	126.13	2.225	3.313	148.87
May	2.945	1.24	42.08	2.97	1.09	36.62	2.995	1.266	42.28
June . . .	1.54	0.52	33.76	1.21	0.18	15.08	1.465	0.346	23.59
July	3.71	0.38	10.33	3.30	0.25	7.59	3.265	0.203	6.23
August . .	3.24	0.22	6.91	3.75	0.14	3.58	4.100	0.166	4.04
September .	2.955	0.29	9.65	3.20	0.30	9.28	2.905	0.20	6.88
October .	2.85	0.36	12.49	3.16	0.42	13.15	3.235	0.256	7.92
November .	4.065	0.86	21.07	4.76	1.20	25.21	4.645	1.145	24.65
December .	4.825	1.40	29.04	5.77	2.10	36.31	4.975	1.793	36.03
Totals and Averages.	45.560	22.30	48.95	46.97	21.92	46.67	46.065	22.498	48.84

Table showing the Temperature of Air and Water at different Stations on the Water-Works.

1886.	TEMPERATURE OF AIR.						TEMPERATURE OF WATER.	
	Chestnut-Hill Reservoir.			Framingham.			Brookline Reservoir.	Mystic Engine-house.
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Mean.	Mean.
January . . .	34.2	14.9	24.5	33.1	15.0	24.0	35.6	33.7
February . . .	36.4	15.9	26.2	35.9	15.1	25.5	36.4	34.0
March	41.5	24.4	32.9	42.7	24.9	33.8	37.9	35.2
April	61.8	38.1	50.0	62.4	38.8	50.6	47.8	45.9
May	69.4	44.6	57.0	70.1	44.8	57.4	58.9	58.6
June	75.3	52.2	63.7	76.1	52.1	64.1	66.0	64.3
July	84.0	57.4	70.7	84.4	57.1	70.7	72.1	72.3
August	81.1	55.5	68.3	80.7	55.1	67.9	72.6	72.1
September . . .	73.1	51.9	62.5	72.4	51.0	61.7	69.2	67.9
October	62.3	39.0	50.6	61.7	37.9	23.8	57.4	57.0
November . . .	50.6	31.5	41.1	50.0	30.5	40.2	45.6	44.2
December . . .	36.3	18.1	27.2	35.0	17.5	26.2	36.4	36.3

WATER REGISTRAR'S REPORT.

JANUARY 1, 1887.

OFFICE OF THE WATER REGISTRAR,
BOSTON, January 1, 1887.

HORACE T. ROCKWELL, Esq., *Chairman Water Board:* —

SIR, — The annual report of the Water Registrar as required by Section 9, Chapter 30, of the Revised Ordinances is herewith submitted.

COCHITUATE WORKS.

The total receipts of the Cochituate Works for the year ending December 31, 1886, have been		$1,235,482 17
The detail of this amount is as follows: —		
Received from sale of water furnished in '86,	$1,083,600 70	
" " " " " 1885,	122,463 99	
" " elevator motor and fire pipes,	4,438 98	
" " service-pipes and repairs,	4,220 39	
" " sale of old material . .	3,163 82	
" " off and on water for repairs,	2,688 10	
" " fines	1,904 20	
" " rent of water-posts . .	360 00	
" " off and on water for non-payment . . .	1,298 00	
" off and on water for waste . .	26 00	
	$1,224,164 18	
Add sundry receipts by Water Board .	11,317 99	
Total		$1,235,482 17

MYSTIC WORKS.

The total receipts of the Mystic Works during the year 1886 have been . .	$254,563 88

The detail of this amount is as follows: —

Received from the sale of water in 1886,	$227,173 37
" " " " " " " 1885,	22,436 25
" " service and fire pipes .	1,204 66
" " sale of old material . .	514 29
" " fines	258 25
" " off and on water for non-payment . . .	256 00
" " off and on water for repairs	253 00
" " sundries	137 64
	$252,233 46
Add sundry receipts by Water Board .	2,330 42
	$254,563 88

The percentage allowed the cities of Somerville, Chelsea, and town of Everett under contract, is as follows: —

Somerville	$23,882 68
Chelsea	18,940 87
Everett	3,483 63
	$46,307 18

The expenditures of this department for the year 1886, are as follows: —

	Mystic.	Cochituate.
For salaries	$7,102 08	$31,125 24
Labor		12,924 29
Printing and stationery . .	839 50	1,705 02
Travelling expenses . . .	158 95	1,057 95
Postage, telephone, etc. . .	512 22	115 27
	$8,612 75	$46,927 77

The estimated income from all sources from the Mystic and Cochituate departments for the year 1887, is $1,492,000 00

	Mystic.	Cochituate.
From water-rates . . .	$277,000	$1,180,000 00
" all other sources . .	5,000	30,000 00
Total	$282,000	$1,210,000 00

The total number of takers supplied by Cochituate Works is	57,010
The total number of takers supplied by Mystic Works is	19,273
The total number of meters now applied to premises of both Cochituate and Mystic Works is	3,884

The following table represents the size, kind, and location of each meter: —

Size and Kind of Meter.	Cochituate Works.	Charlestown.	Chelsea.	Somerville.	Everett.	Total.
⅝ inch Worthington	372	29	10	11	1	423
¾ " "	45	22	17	10	2	96
1 " "	389	41	12	16	1	459
1½ " "	35	1	1	1	....	38
2 " "	63	20	8	7	2	100
3 " "	13	1	....	1	....	15
4 " "	7	5	1	2	....	15
⅝ " Crown	1,054	90	13	10	....	1,167
¾ " "	109	32	6	4	....	151
1 " "	160	10	5	2	....	177
1½ " "	31	1	1	1	....	34
2 " "	23	3	....	2	.. .	28
3 " "	16	4	1	1	....	22
4 " "	9	4	1	....	1	15
6 " "	1	2	....	....	....	3
¾ " Tremont	959	28	6	1	....	994
1 " "	70	6	1	6	....	83
⅝ " Desper	17	....	....	....	....	17
¾ " "	1	....	....	....	....	1
1 " "	2	....	....	. . .	....	2
⅝ " New England	1	....	....	....	....	1
⅝ " Hersey	6	....	....	....	....	6
⅝ " Ball & Fitz	11	....	....	....	....	11
¾ " "	7	1	....	....	....	8
1 " "	5	....	....	....	....	5
2 " "	....	1	....	2	....	3
3 " "	....	....	1	....	....	1
⅝ " Spooner	1	....	....	....	....	1
1 " "	1	....	....	....	....	1
¾ " Fox	1	....	....	....	....	1
½ " Frost	1	....	....	....	....	1
1 " "	1	....	....	....	....	1
1½ " "	1	....	....	....	....	1
⅝ " Balance Valve	3	....	....	....	....	3
Total	3,415	301	84	77	7	3,884

COCHITUATE WORKS.

The following table exhibits the classes of premises to which meters are attached, the amount of water consumed, and the revenue assessed for the year 1886 : —

CLASS OF PREMISES.	1885.		1886.	
	Quantity used. Cubic feet.	Amount Assessed.	Quantity used. Cubic feet.	Amount Assessed.
Hotels	21,255,194	$31,882 29	23,980,000	$29,843 90
Apartment Hotels	56,513,773	84,770 66	41,425,000	56,026 50
Business Premises	64,131,173	96,196 76	64,699,000	86,856 17
Steam Railroads	23,002,380	34,503 57	26,493,000	32,271 40
Sugar Refineries	28,594,000	42,891 00	29,973,000	36,083 00
Factories and Machinists	22,770,093	34,155 13	23,623,000	31,153 63
Iron Works and Foundries	4,402,173	6,603 26	5,963,000	7,428 10
Mills and Engines	2,672,000	4,008 00	3,093,000	4,143 70
Marble and Stone Works	2,275,700	3,413 55	2,263,000	2,922 35
Gas Companies	9,044,432	13,566 67	12,699,000	15,416 90
Breweries	7,626,000	11,439 00	10,409,000	12,896 20
Oil Works	1,690,000	2,535 00	1,709,000	2,158 30
Chemical Works	2,801,000	4,201 50	2,680,000	3,264 00
Laundries	326,000	489 00	437,000	577 80
Restaurants	5,187,300	7,781 00	4,763,000	6,436 40
Stables	10,028,384	15,042 57	11,257,000	15,330 00
Theatres and Halls	738,000	1,107 00	1,223,000	1,602 50
Hospitals	3,610,000	5,415 00	1,986,000	2,484 60
Schools	2,884,893	4,327 34	2,814,000	3,791 30
City, State, and Government Buildings	7,620,686	11,431 00	9,548,000	11,956 10
Steamers and Shipping	7,526,000	11,416 76	7,846,000	9,986 60
Elevators and Motors	12,824,833	19,237 24	15,222,000	20,461 90
Electric Light Companies	3,248,874	4,873 30	4,280,000	5,248 20
Miscellaneous	1,116,667	1,675 00	1,776,000	2,367 30
Total	301,889,560	$452,961 60	310,161,000	$400,706 85

MYSTIC WORKS.

The following table exhibits the Classes of Premises to which Meters are applied, the amount of Water consumed, and the Amount assessed for the Years 1885 and 1886: —

CLASS OF PREMISES.	1885.		1886.	
	Quantity used. Cubic feet.	Amount Assessed.	Quantity used. Cubic feet.	Amount Assessed.
Steam Railroads	18,108,785	$27,163 17	21,225,860	$25,705 40
Horse Railroads	929,059	1,393 58	999,353	1,333 43
Hoosac Tunnel Dock and Elevator Co.	997,200	1,495 80	1,333,037	1,623 64
City and Government Buildings	5,772,367	8,658 53	6,523,518	8,127 32
Schools	882,862	1,324 28	853,956	1,189 13
Stables	1,965,474	2,948 16	1,945,374	2,634 91
Factories	5,311,874	7,967 82	5,639,307	7,624 65
Chemical Works	963,331	1,445 00	1,033,113	1,409 98
Foundries	785,480	1,178 25	759,946	1,073 75
Breweries	932,463	1,398 69	816,000	1,041 30
Gas Companies	209,420	314 13	279,960	369 97
Oil Works	178,174	267 29	131,575	179 59
Mills and Engines	835,530	1,253 30	760,835	1,067 39
Hotels	427,755	641 64	481,989	657 20
Model Houses	1,557,896	2,336 86	1,910,633	2,611 47
McLean Insane Asylum	1,643,610	2,465 39	1,320,780	1,608 63
Slaughter-houses	2,454,816	3,682 21	2,439,370	2,975 30
Business Purposes	624,254	936 40	640,703	897 61
Wharves	749,648	1,124 50	429,792	586 76
Laundries	399,888	599 86	386,730	548 60
Elevators and Motors	109,758	164 61	99,144	139 30
Bakeries	425,380	638 09	454,705	621 64
Restaurants	227,266	340 94	145,000	203 90
Tanneries	1,077,096	1,615 62	988,458	1,265 68
Miscellaneous	1,849,815	2,774 75	2,791,000	3,833 93
Total	49,419,201	$74,128 87	54,390,138	$69,330 48

The quantity used through meters in the different districts was as follows: —

	1885.		1886.	
	Cubic feet.	Amount.	Cubic feet.	Amount.
Charlestown	34,202,376	$51,303 50	38,896,106	$48,532 81
Somerville	8,209,761	12,314 72	7,864,843	10,118 67
Chelsea	5,868,046	8,802 11	6,331,974	8,894 97
Everett	1,139,018	1,708 54	1,297,215	1,784 03
Total	49,419,201	$74,128 87	54,390,138	$69,330 48

The following table exhibits the yearly revenue from the sale of Cochituate water since its introduction into the city, October 25, 1848: —

Received by Water Commissioners, as per Auditor's report, in 1848				$972 81
From January 1, 1849,	to January 1,	1850		71,657 79
" "	1850, "	1851		99,025 45
" "	1851, "	1852		161,052 85
" "	1852, "	1853		179,567 39
" "	1853, "	1854		196,352 32
" "	1854, "	1855		217,007 51
" "	1855, "	1856		266,302 77
" "	1856, "	1857		282,651 84
" "	1857, "	1858		289,328 83
" "	1858, "	1859		302,409 73
" "	1859, "	1860		314,808 97
" "	1860, "	1861		334,544 86
" "	1861, "	1862		365,323 96
" "	1862, "	1863		373,922 33
" "	1863, "	1864		394,506 25
" "	1864, "	1865		430,710 76
" "	1865, "	1866		450,341 48
" "	1866, "	1867		486,538 25
" "	1867, "	1868		522,130 93
" "	1868, "	1869		553,744 88
" "	1869, "	1870		597,328 55
" "	1870, "	1871		708,783 68
" "	1871, "	1872		774,445 70
" "	1872, "	1873		862,704 08
" "	1873, "	1874		917,415 92
" "	1874, "	1875		977,020 48

From January 1, 1875,	to	January 1, 1876	.	1,005,120	94
" " 1876,	"	1877	.	1,029,643	70
" " 1877,	"	1878	.	1,015,562	89
" " 1878,	"	1879	.	1,010,584	30
" " 1879,	"	1880	.	1,025,803	14
" " 1880,	"	1881	.	1,039,896	17
" " 1881,	"	1882	.	1,087,528	49
" " 1882,	"	1883	.	1,127,982	32
" " 1883,	"	1884	.	1,167,704	17
" " 1884,	"	1885	.	1,203,192	55
" " 1885,	"	1886	.	1,239,757	99
" " 1886,	"	1887	.	1,206,064	69

The following table exhibits the yearly revenue from the sale of Mystic water since its introduction, November 29, 1864: —

From November 29, 1864,	to	January 1, 1866		$27,045	10
" January 1, 1866,	to	January 1, 1867	.	47,247	16
" " 1867,	"	1868	.	60,188	83
" " 1868,	"	1869	.	72,448	12
" " 1869,	"	1870	.	100,490	57
" " 1870,	"	1871	.	176,780	22
" " 1871,	"	1872	.	201,822	65
" " 1872,	"	1873	.	232,674	05
" " 1873,	"	1874	.	253,710	10
" " 1874,	"	1875	.	276,058	47
" " 1875,	"	1876	.	292,058	78
" " 1876,	"	1877	.	294,857	50
" " 1877,	"	1878	.	282,915	60
" " 1878,	"	1879	.	279,743	61
" " 1879,	"	1880	.	266,606	46
" " 1880,	"	1881	.	269,979	83
" " 1881,	"	1882	.	235,642	74
" " 1882,	"	1883	.	245,981	85
" " 1883,	"	1884	.	260,791	28
" " 1884,	"	1885	.	262,243	50
" " 1885,	"	1886	.	279,096	70
" " 1886,	"	1887	.	301,011	93

The daily returns from the Service Division represent a total of 9,643 orders received during the year, as follows: —

Application for service-pipes	1,734
" " turning on water for first time .	1,724
" " repairs in service-pipes . .	854
" " off and on water for repairs .	3,807
" " " " " non-payment	1,475
" " " waste	49
Total	9,643

Drinking-Fountains.

The total number of drinking-fountains established to Jan. 1, 1887, is 73, all of which, with the exception of 12, have automatic fixtures to prevent the flow of water.

They are distributed as follows, viz. : —

City Proper	21
East Boston	4
South Boston	9
Roxbury	7
West Roxbury	5
Dorchester	5
Brighton	5
Charlestown	6
Chelsea	4
Somerville	6
Everett	1
	73

Hydraulic Motors.

The total number of hydraulic motors now located is 75, being a decrease of 10 during the year 1886. They are applied to a variety of business premises, church organs, etc.

Hydraulic Elevators.

The total number of hydraulic elevators established to date is 273, being an increase of 18 over the previous year. They are located principally in business premises and apartment-houses.

Water-Posts.

There are 110 water-posts now located for street-sprinkling purposes, being an increase of 82 during the past year.

They are located as follows : —

Boston Proper	4	Brighton	16
South Boston	4	Charlestown Dist.	6
East Boston	1	Chelsea	3
Roxbury	13	Somerville	25
Dorchester	15	Everett	6
West Roxbury	17		

Table showing the Number and Kind of Water-Fixtures contained within the Premises of Water-takers to January 1, 1887.

	Taps.	Sinks.	Bowls.	Bath-tubs.	Water-Closets.				Wash-tubs.	Automatic Urinals.	Plain Urinals.
					Street Pressure.	Tank Pressure.	Hopper.	Waste.			
City Proper	5,669	53,845	38,960	12,658	16,999	23,046	176	436	17,800	3,442	800
East Boston	573	9,134	1,257	709	2,821	857	6	25	511	30	18
South Boston	955	16,530	2,720	1,413	5,087	2,401	41	166	1,402	89	44
Dorchester	1,795	6,567	3,376	2,274	1,341	3,174	9	36	3,170	20	7
Boston Highlands	1,878	13,610	6,397	4,010	4,683	5,468	10	35	5,385	80	16
West Roxbury and Brighton	1,449	5,401	2,355	1,635	1,230	2,332	3	106	2,323	39	30
Total	12,319	105,087	55,065	22,699	32,161	37,278	245	804	30,591	3,700	915
Charlestown District	1,403	10,803	2,170	1,090	3,613	1,980	17	129	1,094	84	36
Chelsea	1,025	7,644	1,912	1,212	2,624	1,420	8	28	1,082	40	46
Somerville	2,177	8,507	2,488	1,942	2,855	2,243	27	46	1,613	32	27
Everett	402	1,485	303	288	116	280	. . . . .	4	161	1	3
Total	5,007	28,439	6,873	4,532	9,208	5,923	52	207	3,950	157	112

Respectfully submitted,

WM. F. DAVIS, *Water Registrar.*

REPORT OF THE SUPERINTENDENT OF THE WESTERN DIVISION.

Chestnut-Hill Reservoir, Jan. 1, 1887.

Col. H. T. Rockwell, *Chairman Boston Water Board:* —

Sir, — The annual report for the Western Division of the Boston Water-Works is submitted herewith.

Sudbury-river Basins.

Basins 1, 2 and 3 are full, and water is now wasting over the lowest dam into the river. Basin 3, as a storage-basin, has not been in use during the whole year, owing to the work which has been going on for the improvement of its shallow flowage.

The quality of the water in Basin 2 has been excellent, except at times when water was drawn from Basin 4. This latter basin was drawn upon throughout the summer and autumn and it is now filling rapidly.

These are the principal facts in regard to the Sudbury supply. A more detailed account will be found under each basin.

Basin 1.

On Jan. 1, 1886, the water in this basin stood at grade 158.02 above tide-marsh level in Boston, and water was wasting over the dam.

The water as a general rule was of fair quality. On March 19 the waste-gates were opened to lower the surface, so that Basin 3 might be emptied. On June 4 the gates were shut, the basin at that time being at elevation 154.94. This height did not vary much until Nov. 24, when a steady rise began, and, on Dec. 19, water began to waste over the stone crest and so continued to the present date.

The lowest point reached during the year was on Nov. 12, viz. : 154.02, and the highest on Feb. 14, viz. : 160.13. The flow of one and one-half millions per day has been passed into the river every day during the year in accordance with the law. The usual amount of care has been given to the

maintenance of the works around the basin. In addition to this a new barn has been built on the foreman's place, the Homer estate sold at public auction, and all the materials owned by the city and stored on these grounds have been removed.

On February 10 there was quite a body of snow on the ground, probably equivalent to two inches of rainfall. At 7 P.M., on the above day, rain began to fall, and continued until noon of the 15th. The total rainfall on the Sudbury-river water-shed was 4.64 inches, but adding the snow on the ground would increase this amount to over six inches. The greatest freshet that I have ever seen on the works followed. The snow melted but slowly at first, or the flow of the streams would have been even larger than it was. On the 14th the waste over dam 1 was 1,326,300,000 gallons, and on the 13th the yield of the river was very nearly two billions of gallons in 24 hours. The total waste over the lowest dam from the 11th to the 18th, inclusive, was 5,853,200,000 gallons, and the total yield of the river during the same period was 6,504,800,000 gallons. The weather during the freshet was mild, and the snow was practically all melted from the ground. The maximum rate of yield from the river was from 7 A.M. to noon of the 13th, and was at the rate of 2,136,000 gallons in 24 hours.

The following table shows the progress of the freshet more in detail: —

Date.	Waste over Dam 1. Millions Gallons.	Yield of River. Millions Gallons.
February 11 . . .	105.8	149.6
" 12 . . .	412.6	918.6
" 13 . . .	1,174.7	1,994.7
" 14 . . .	1,326.3	1,287.3
" 15 . . .	1,059.1	837.8
" 16 . . .	815.3	531.0
" 17 . . .	521.3	428.7
" 18 . . .	438.1	357.4
Totals	5,853.2	6,505.1

No damage was done to any part of the works, though the B. and A. R.R. arch, at Lake Cochituate, was washed away, and the trains blocked on that road for several days.

Attention has already been called in previous reports to the defects in the 48-inch pipe-line in Basin 1. It is hoped that they may be remedied during the coming season.

Basin 2.

On January 1, 1886, this basin stood at grade 166.11, and water was wasting over the stone-crest. This continued until April 28, when both sets of flash-boards were put upon the dam. Water flowed over the top of these flash-boards from May 1 until May 31. On June 4 the height of the basin was still further raised by means of temporary planks, placed on the regular flash-boards so as to bring the surface up to 167.50. On June 16 waste over these boards stopped, and as the water was used for the city's supply the surface fell to 155.15 on August 5, at which time water from Basin 4 was drawn into this basin to maintain its level. From this time until November 15, Basin 2 was kept between the 156. and 157. grade. Under the influence of rains the water began to rise, and on November 28 was flowing over the stone-crest which continued with slight exceptions until the present time. The highest elevation reached during the year was 167.53 on June 13, and the lowest, 155.15, on August 5.

No work of any importance has been done at Basin 2 during the year, with the exception of the ordinary routine work attending the maintenance of the dams and gate-house, and the management of the water.

Allusion has been made to the quality of the water when Basin 4 was let on to the supply. At a distance of ten feet below the surface the water in Basin 4 had a bad smell, and this was so persistent that it was noticed as far down as the Farm-pond gate-house, when water was run directly through the Farm-pond conduit, but by allowing the water to oxidize in Farm Pond the objectionable smell entirely disappeared and the water became clearer in color.

This bad smell in water at certain depths below the surface is often noticed in storage reservoirs, and provision should always be made to draw from the surface when necessary.

Basin 3.

The water from this basin has been drawn off during the entire year, with the exception of a few days when it was filled by the great freshet in February. A large force of men and teams has been employed in removing the shallow flowage from the sides and at the upper end of the basin, destroying stumps, etc. Some 280,000 cubic yards of earth have been moved in improving the basin, and about 7,000 square yards of paving and riprap put in place, and about twelve thousand stumps removed and destroyed. A detailed

report has been submitted to the City Engineer showing the amount of work done and its progress. All the sides have been deepened, so that there is nowhere less than ten feet of water when the basin is full. The excavated material, muck, loam, etc., was used in filling the shallower portions. It does not seem possible that this work could have any other effect than to improve the quality of the water stored in this basin. During the summer the water which ran down the orginal bed of the stream was turned into Farm Pond, and then used for the city supply. Advantage was taken of the low state of the water to overhaul and paint the gates in the gate-house, and to do other work required below the water-line.

On October 9 the gates were shut, and the water allowed to accumulate; and, on December 1, grade 167, which is the grade of the limit of shallow flowage, was reached, and by the last of the month the basin was full and running over.

The highest elevation reached by the water during the year was 175.61, on December 29, and the lowest 154.25, on August 30. The surface was kept at about 154.75 while the work on the shallow flowage was in progress.

Basin 4.

On January 1 the water in this basin stood at elevation 193.65. It gradually rose, and, on February 12, reached grade 202.87. After this date the water accumulated rapidly, and, on February 15, was wasting over the overflow in the gate-house at grade 210.21. On February 17 the water rose to 211.65, when the outlet gate was opened and the basin maintained at 210 until March 2.

On March 31 the stop-planks having been put into the gate-house and the outlet gate closed, waste began over the stone-crest of the overflow, which continued until June 3, when temporary stop-planks were added to the stone work, and the water carried up to 214.60. On August 4 the first use of the basin, as a storage-reservoir, to reinforce the supply to the city began, and the gates were opened. On November 1 the surface had fallen to 197.36, when the gates were closed, and the surface allowed to rise to 204.93, which is the level at the present date. The highest point reached during the year was 215.03, on April 7, and the lowest 193.65, on January 1, 1886. The elevation of the stone-crest of the overflow is at grade 214.21, and as high-water mark is at grade 215.21, I recommend that a bridge over the weir be built, and provision be made for raising the water to this level after the first of July, when any freshet can be easily handled.

The total amount of water received from Basin 4 during the year was 2,710,000,000 gallons, equal to about 56 per cent. of the rainfall. At request of the City Engineer I took charge of the work of completing the grading of the dam and the improvement of the grounds at this basin. From the first of April until the first of July a force of about 30 men were employed. The loam on the embankment of the dam was graded, and sown to grass; about 33,500 sq. feet of sodding placed along the paths and on the south side of the embankment. About 1,200 cart-loads of additional loam was purchased, and about 250 trees set out in portions of the grounds, that it seemed desirable to treat in this way. About 550 feet of 6-inch and 1,050 feet of 4-inch tile drain-pipe was laid, besides 270 feet of 6-inch Akron pipe, 800 feet of stone drain, and 900 feet of open ditch excavated all for the purpose of draining the ground below the dam. Wells, catch-basins, and weirs were built at proper places. There is still a certain amount of work remaining to be done at the brook channel, and it would be very desirable to build a small house for the gate-keeper, where he could keep a constant watch of this important basin. I therefore recommend that this be done at the earliest opportunity.

Farm Pond.

On Jan. 1, 1886, this pond stood at elevation 149.33, high-water mark. It was kept at this point without material change until March 24, when it was drawn down to allow work on the Farm-pond aqueduct to proceed. April 14 found the water at grade 145.02 which was maintained until Oct. 27 when it rose slowly to 145.90, on Nov. 19. It was then filled up rapidly from the basins above, and early in December had reached high-water mark, where it remained for the rest of the year. The highest elevation was 149.91, on Feb. 15, and the lowest 144.86, on June 15.

Early in July the Farm-pond aqueduct was so far completed that on the 9th of July water was run through it to Chestnut-Hill reservoir; but owing to trouble in the quality of the water from Basin 4, the flow was changed into the pond after a few days. On Sept. 9 owing to the presence of a small quantity of algæ in Farm Pond the flow was again turned through the aqueduct. On Oct. 4 all trace of algæ having disappeared water was again drawn directly from Farm Pond. Between Nov. 21 and Nov. 29 water was run through the aqueduct to give Basin 3 water an opportunity to oxidize and settle before using as a portion of the supply. In general the effect of drawing from the lower end

of the pond is to improve the color and quality of the Sudbury water. Some repairs have been made to the sluice in Farm Pond and to the masonry of the inlet chamber. During the year the regular force employed at the basin has worked very largely on the shallow flowage in Basin 3 and also on construction at Basin 4, so that the grounds in the immediate vicinity of the gate-houses and dams have not been kept up to the usual standard, this part of the regular work having been somewhat neglected for more important duties.

The Farm Pond Water Co. have pumped during the year 76,600,000 gallons from Farm Pond, or a daily average of 210,000 gallons.

Lake Cochituate.

On Jan. 1, 1886, the surface of the lake stood at 131.47, 2.89 feet below high-water mark. On Jan. 28, the water having risen to 132.28, the gate in the upper dam was opened and waste into the river began. This continued until the middle of April, when the stop-planks were put in the dam. The greatest amount of water passed over the lower dam during this time was 1,975 feet, on Feb. 15. On Jan. 17 the lake had reached high-water mark. The surface fell steadily during the summer, and on Nov. 17 it reached the lowest point, viz.: 127.47. From this date to the present time, under the influence of abundant rains, it rose to 129.77, on Jan. 1, 1887. The quality of the water has been excellent throughout the year. Strenuous efforts have been made to keep out all the drainage from Pegan Brook, and I am glad to say that the condition of the water has never been so good. There is now no sewerage emptying into Pegan Brook that can be found by the most minute system of inspection. The water is bright and clear in appearance. I think it would be an improvement to the water of the lake to take away the filter dams, so-called, and also the dam at the outlet of the meadows.

An inspector has been kept at work during the greater part of the year on different portions of the Western Division, wherever any danger from sewage contamination occurs.

At Natick, Framingham, Marlboro', Ashland, Woodville, Cordaville, and Brookline, 227 cases have been inspected, and 120 cases abated. Six injunctions have been served.

A sewer has been built in Chestnut-Hill avenue, Brookline, mainly through the efforts of the city, and partly at its expense, to relieve the sewerage troubles at the Brookline tunnel of the Cochituate aqueduct.

On May 21 the buildings surrounding the boilers at the gate-house were burned, and considerable damage done to the machinery. The pumps and engines have been removed to the other side of the lake, and two of the damaged boilers have been disposed of. The others might be sold whenever an opportunity offers.

In September a leak was noticed in the lower of the two dams at the outlet of the lake. An excavation was made in the centre of the embankment, and it was found that the cement was all gone from some portions of the stone-work. Certain portions of the sheet piling were found in a decayed condition, and after a thorough repair of the masonry a brick pier was built to take the place of portions of the rotten piling removed. An abundant amount of cement was used for plastering the surfaces of the masonry, and it is believed that no further trouble will arise from this particular source. Some repairs were also made at the same time to the temporary portions of the wing-walls of this dam, and the masonry of the upper dam was pointed.

No water from Sudbury river has been run into the lake during the year. The condition of the water in the arm of the lake running from Beaver Dam Brook was very bad during the summer and autumn. Thick masses of slimy vegetation collected on the surface and were removed from time to time; but they never succeeded in getting beyond a very restricted area, and probably had little or no influence on the quality of the water in the main portions of the lake. Surveys will soon be started with reference to improving these shallow margins.

Dudley Pond.

This pond is now nearly full. We have had no occasion to draw water from this source during the year.

Sudbury–river Aqueduct.

This structure has been in service during the entire year, with the exception of a few days while undergoing cleaning, once in February, during the great freshet, and once in November while Farm Pond was being filled from Basin 3. It has carried to the city a total of 5,267,600,000 gallons, or an average of 14,430,000 gallons daily.

This average is larger than that of last year. The greatest amount run in any one day was 38,900,000 gallons, on Dec. 27, and the least 6,600,000 gallons, on Jan. 21.

On July 27, 28, and 29, the whole length of the Farm-pond

and Sudbury aqueducts were cleaned as thoroughly as possible by day-labor. From the gate-house to Bacon's waste-weir the brick-work was very dirty, being covered with many patches of fibrous growth which held mud. On the bottom a luxuriant growth of sponge was found in two continuous lines on each side of the bottom. The growth was generally from three to ten inches in diameter, and it must have developed entirely since the last cleaning. From Bacon's waste-weir to Waban bridge the spongilla gradually diminished. From the East-pipe chamber to Chestnut-Hill reservoir the aqueduct was tolerably clean. There was some sponge found in the Beacon-street tunnel. Four cart-loads of stone were removed near Station 803, which had fallen from the roof. Nothing has yet been done towards bricking up this portion of the aqueduct, but it should be undertaken without delay.

On Dec. 3 a leak was discovered coming from the Waban arches. It appeared in the "tell-tale" pipe in the second arch from the west end of the bridge. The water was shut off at once, and a crack fifty feet in length found in the bottom of the aqueduct, through which the water was escaping. It was thoroughly repaired. It extended from Station 383+01 to Station 383+48. The iron fences on Charles river and Waban bridges were painted during the summer. The embankments and other portions of the exterior of the aqueduct have received the usual attention in the way of loaming, seeding, etc.

The great freshet in February gave an excellent opportunity to test the capacity of the various water-ways along the aqueduct to pass the water from their respective watersheds. It was seen that they were all unobstructed, and in proper working order at the beginning of the flood. The following table shows the head of water existing at the various points of interest: —

	Feet.
Beaver Dam Brook	2.16
Course Brook waste-weir . . .	3.16
Culvert, No. 14 (near Cottage street) .	0.46
" " 15 (near Bacon waste-weir)	0.46
Bacon's waste-weir	1.88
Fuller's " "	0.16
Rosemary brook	0.50
Wardwell's culvert (No. 41) . . .	0.04

The water at Charles-river bridge reached a point 5.75 feet below the spring of the great arch, and at Waban bridge it rose 0.58 feet above the cap stones of the piers.

Owing to the faithfulness of Mr. J. W. Oldham, foreman of the aqueducts, no damage was done at any point on the line.

Fourteen hundred feet of new fencing has been built during the year.

On Dec. 29, 30, and 31, the second cleaning of the aqueduct took place.

No sponge was found to speak of, but a fibrous vegetable growth extended along the sides and bottom which could not be entirely removed with twenty strokes of a stiff broom. It was generally about two inches thick.

A small portion of the aqueduct was cleaned by a machine, enough to show the practicability of this method of cleaning. The machine did the work in a much more thorough manner than it could be done by hand, and proceeded at the rate of about 100 feet in a minute. Further experimenting in this direction will be made.

The aqueduct force was employed for a considerable portion of their time at Dam No. 4, under Mr. Oldham, where their experience in seeding, sowing, and sodding embankments came in excellent play.

The Cochituate Aqueduct.

On Jan. 1, 1886, a depth of five feet and one-half of water was run to the reservoirs, and so maintained until Aug. 3, when the water was shut off for cleaning. From Aug. 6 to Dec. 23, when the second cleaning took place, five feet of water was maintained.

Spongilla was found at the time of the first cleaning in considerable quantity as far as Station 129, but from this point to the west-pipe chamber the amount diminished. It was in its first stages of growth when it is removed quite easily. From Newton Center water-weir to Chestnut-Hill reservoir the spongilla increased in quantity, and between Chestnut-Hill and Brookline reservoir nearly the whole area of the brick-work was covered with it. At the second cleaning, in December, very little spongilla was found in any portion of the aqueduct, but a black mossy growth of vegetation had taken its place.

In August the bushes growing on the line from Newton Center to the lake were removed.

The following table will show the head of water on the different culverts, etc., at the time of the great freshet in February : —

	Feet.
Stevens' culvert	0.71
Dadman's brook	0.42

Morton culvert	0.42
Newton Center waste-weir . .	0.08
Charles-river bridge . . .	0.66

At the last-named structure the water reached a level of 5.42 ft. below the key-stone of the middle arch of the bridge. There would have been a much greater head of water on this bridge had not the water dammed back by the next bridge below, giving a greater cross-section, and consequently a lower velocity to the stream.

Nearly half a mile of new fencing has been built during the year and old fences maintained.

No repairs have been made to the interior.

Chestnut-Hill Reservoir.

This reservoir has been in constant use throughout the year. The water has been good in quality. The grounds are in excellent condition. An improvement has been made in the appearance of the drive-ways by taking down the fences wherever practicable. Holes have been dug and filled preparatory to the planting of another row of elms in the spring.

The stone-crusher has been used very little on account of lack of appropriation. The usual meteorological and other observations have been made. All of the gate-houses and other structures are in good repair with the exception of the screens at the effluent gate-house.

About 40 tons of hay were cut from the grounds during the year.

Chestnut-Hill Drive-way.

The maintenance of this drive-way has always been supported from an annual appropriation by the City Council. This year $1,500 only was appropriated, — a sum entirely insufficient to pay for watering and the repairs of the road.

Whatever has been found actually necessary to be done, however, has been taken from the regular income of the Water-Works.

Next year a larger sum than usual must be spent to make up for repairs postponed for lack of funds.

Brookline Reservoir.

The grounds and structures at this point are in good order. About half the water used in Boston has been sent through this reservoir. The old stone posts and chain fence

in front of the gate-house have been removed, some trees cut down, and the banks graded and sodded, very much to the improvement, of the surroundings. The usual daily records have been kept.

A table of rainfall at Chestnut-Hill reservoir is appended, showing the times of beginning and ending of each storm.

Very respectfully,

DESMOND FITZGERALD,
Superintendent.

Table of Rainfall at Chestnut-Hill Reservoir for year ending Dec. 31, 1886.

DATE.	Inches.	Snow or Rain.	Duration.
Jan. 5	1.04	Rain	3.30 a.m to 4.00 p.m.
" 9	1.45	Snow	1.00 a.m to 4.15 p.m.
" 19	0.79	Snow and Rain	6.00 a.m to 8.00 p.m.
" 21	0.21	Rain	9.00 p.m. to 8.00 p.m.
" 22			
" 24	0.84	Snow and Rain	10.15 a.m. to 9.30 p.m.
" 25			
" 27	1.67	Rain	6.15 p.m. to 6.45 p.m.
" 28			
" 29	0.66	Rain and Snow	11.20 a.m. to 8.15 a.m.
" 30			
" 30	0.49	Snow	5.00 p.m. to 11.55 p.m.
" 31	0.02	"	6.30 p.m. to 11.45 p.m.
Total .	7.17		
Feb. 3	0.06	Snow	9.00 p.m. to 3.00 a.m.
" 4			
" 11	6.09	Rain	8.50 a.m. to 1.00 p.m.
" 12			
" 13			
" 19	0.68	"	5.40 p.m. to 11.55 p.m.
" 21	0.01	Snow	during evening.
" 25	1.05	Rain and Snow	11.15 a.m. to 4.30 p.m.
" 26			
Total .	7.89		
Mar. 8	0.07	Snow	7.40 p.m. to 11.15 a.m.
" 9			
" 12	0.37	Rain and Snow	4.00 p.m. to 10.30 p.m.
" 13			
" 16	0.05	Rain	8.55 a.m. to 9.15 a.m.
" 19	2.02	Snow and Rain	5.20 p.m. to 3.00 a.m.
" 20			
" 21			
" 22			
" 22	0.03	Snow	during night.
" 27	0.37	Rain and Snow	5.30 p.m. to 5.00 a.m.
" 28			
" 29	0.64	Rain	6.30 p.m. to 7.00 a.m.
" 30			
" 31			
Total .	3.55		
April 1	0.04	Rain	12.40 a.m. to 1.00 a.m.
" 3	0.10	Snow	6.30 a.m. to 3.30 p. m.
" 5	2.36	Rain	5.45 p.m. to 1.30 a.m.
" 6			
" 7			
" 7	0.02	"	12.30 p.m. to 1.30 p.m.
" 13	0.08	Showers	10.00 a.m. to 3.00 p.m.
" 24	0.04	"	4.20 p.m. to 8.30 p.m.
" 27	0.07	Rain	8.15 p.m. to 11.15 p.m.
Total .	2.71		

Table of Rainfall at Chestnut-Hill Reservoir. — Continued.

DATE.	Inches.	Snow or Rain.	Duration.
May 5	0.04	Rain	1.00 a.m. to 4.00 a.m.
" 5	0.25	"	5.10 p.m. to 11.00 p.m.
" 8	1.54	"	4.20 a.m. to 2.00 a.m.
" 9			
" 10	0.31	"	7.00 p.m. to 7.00 p.m.
" 11			
" 14	0.02	"	2.30 a.m. to 4.45 a.m.
" 16	0.79	"	5.00 a.m to 11.45 a.m.
" 20	0.05	Shower	5.50 p.m. to 7.00 p.m.
" 25	0.25	Rain	8.35 a.m. to 4.00 a.m.
" 26			
" 27	0.05	"	4.45 p.m. to 11.30 p.m.
" 31	0.11	"	4.35 a.m. to 5.10 a.m.
Total .	3.41		
Juue 3	0.55	Rain	6.45 a.m. to 12.15 p.m.
" 9	0.06	"	10.00 p.m. to 3.45 a.m.
" 10			
" 13	0.31	"	5.25 a.m. to 3.00 a.m.
" 14			
" 15	0.15	"	2.00 a.m. to 7.00 a.m.
" 17	0.03	Showers.	during day.
" 23	0.26	Showers and Mist	11.30 a.m. to 4.30 a.m.
" 24			
" 25			
" 25	0.02	Showers	12.30 p.m. to 4.30 p.m.
Total .	1.38		
July 15	1.74	Rain.	5.00 a.m. to 12.30 p.m.
" 15	0·42	"	3.00 p.m. to 10.45 a.m.
" 16			
" 27	0.18	"	4.15 a.m. to 3.30 p m.
" 29	0.25	"	4.45 p.m. to 6.15 p.m.
" 30			1.00 a.m. to 3.00 a.m.
Total .	2.59		

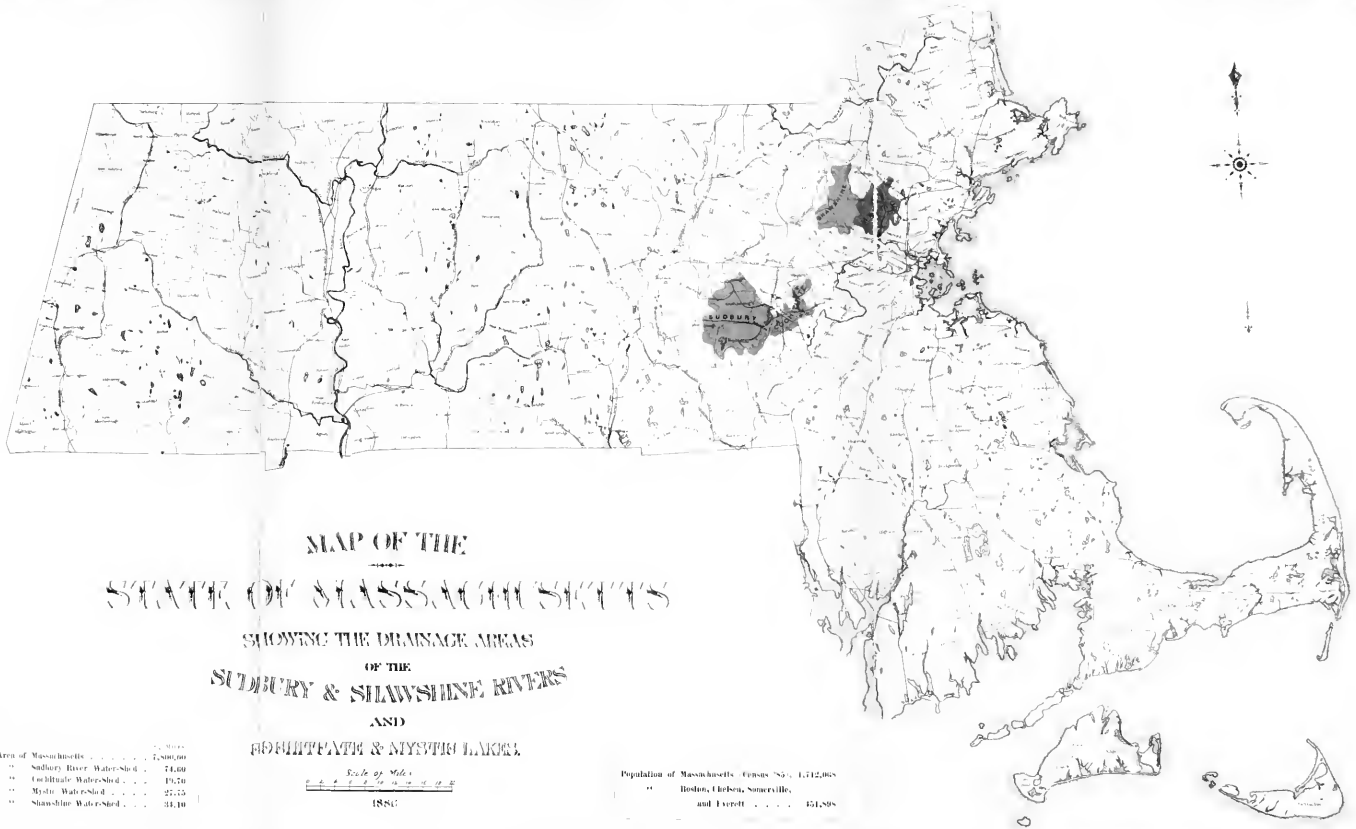
DATE.	Inches.	Snow or Rain.	Duration.
Aug. 2	0.30	Rain.	12.05 a.m. to 3.30 a.m.
" 5	0.40	"	8.15 p.m. to 6.30 a.m.
" 6			
" 7	1.22	"	5.00 p.m. to 6.00 a.m.
" 8			
" 12	0.23	Shower.	3.25 p.m. to 4.10 p.m.
" 14	0.18	Rain.	11.40 a.m. to 1.40 p.m.
" 16	0.63		9.00 p.m. to 1.00 a.m.
" 17			
" 30	0.10	Showers.	1.00 p.m. to 9.00 p.m.
" 31	0.46	Rain.	1.45 p.m. to 7.00 p.m.
Total .	3.52		
Sept. 10	0.41	Rain.	3.00 a.m. to 9 a.m.
" 12	0.46	"	7.15 p.m. to 3.00 am.
" 13			
" 16	0.22	"	6.10 a.m. to 12.30 a.m.
" 17			
" 17	0.15	Shower.	9.15 p.m. to 11.00 p.m.
" 19	0.05	"	9.30 p.m. to 10.45 p.m.
" 23	1.29	Rain.	6.00 a.m. to 6.45 p.m.
" 27	0.45	"	3.00 a.m. to 7.00 p.m.
" 28			
Total .	3.03		
Oct. 12	0.02	Rain.	5.15 p.m. to 7.30 p.m.
" 18	0.09	"	1.30 a.m to 4.00 a.m.
" 26	3.10	"	10.00 p.m. to 11.55 p.m.
" 27			
" 28			
" 29			
" 30			
" 31			
Total .	3.21		

Table of Rainfall at Chestnut-Hill Reservoir. — Concluded.

DATE.	Inches.	Snow or Rain.	Duration.
Nov. 6	0.84	Rain.	11.30 a.m. to 4.00 a.m.
" 7			
" 10	0.17	"	1.15 p.m. to 4.00 p.m.
" 12	1.32	Rain and Snow.	6.20 p.m. to 10.15 p.m.
" 13			
" 17	0.65	Rain.	8.30 a.m. to 4.10 p.m.
" 18			
" 23	0.53	"	3.30 a.m. to 10.30 p.m.
" 25	0.37	"	2.40 p.m. to 1.00 a.m.
" 26			
" 30	0.15	"	10.30 p.m. to 11.40 p.m.
Total .	4.03		

DATE.	Inches.	Snow or Rain.	Duratian.
Dec. 2	0.04	Snow.	4.40 a.m. to 6.30 a.m.
" 5	1.13	"	8.15 a.m. to 11.55 p.m.
" 7	0.40	"	5.00 a.m. to 11.00 p.m.
" 13	0.21	Rain.	7.30 a.m. to 5.30 p.m.
" 16	0.41	Snow.	4.00 a.m. to 4.15 p.m.
" 18	1.13	Rain.	11.30 a.m. to 11.50 p.m.
" 24	1.37	"	6.30 a.m. to 5.40 a.m.
" 25			
" 30	1.13	Snow and Rain.	1.00 a.m. to 11.50 p.m.
" 31			
Total .	5.82		

Total rainfall for year 48.31



MAP OF THE
STATE OF MASSACHUSETTS

SHOWING THE DRAINAGE AREAS
OF THE
SUDBURY & SHAWSHINE RIVERS
AND
HOBBITTATE & MYSTIC LAKES.

Scale of Miles

1887

	Square Miles
Area of Massachusetts	7,800.00
" Sudbury River Water-Shed	74.60
" Cochituate Water-Shed	19.70
" Mystic Water-Shed	22.55
" Shawshine Water-Shed	34.10

Population of Massachusetts (Census 1885)	1,742,085
" Boston, Chelsea, Somerville, and Everett	451,895

REPORT OF THE SUPERINTENDENT OF THE EASTERN DIVISION.

January 1, 1887.

Horace T. Rockwell, Esq., *Chairman Boston Water Board:* —

Sir, — In accordance with the requirements of the Board I herewith present my report for the year ending with December, 1886.

The raising of the 48-inch main, on Beacon street, to conform to the new grade, commencing near the junction of Brookline avenue, and extending about 1,850 feet, was, during the season, successfully performed, and is, up to date, in excellent condition. The laying of the new high-service pipes (30 and 24-inch) was resumed last spring, and will be completed early this season.

The laying of the West Roxbury high-service was commenced October 1, completed, and water let into them on December 23. There has been but one breakage in the large mains during the year. This was on the 48-inch line, at the abutment wall of the Boston & Albany Railroad bridge, on Beacon street; and previous to the raising of that line of pipes, the water was shut off before any damage was done, and repaired very soon after.

Main Pipe.

The length of pipes of the different sizes laid and relaid during the year is 87,197 feet, or 16.51 miles.

Whole length laid since the commencement of the works	466.56 miles
Whole length now in service	414.17 miles

Service-Pipes.

Whole number put in last year	1,590
Length in feet	45,867
Total number to date	53,400

HYDRANTS AND STOPCOCKS.

194 hydrants and 238 stopcocks established during the year.

Relaying of Enlarged Sizes.

Street.	Between what streets.	Size now.	No. of feet.	Size formerly.
Broad	State and Milk	8	478	6
Broad	State and India sq.	12	703	6
Milk	India and Batterymarch	12	420	6
Dock sq. and Union	Washington and Hanover	12	792	6
Charlestown	Causeway and Stillman	12	1,160	6
Lowell	Brighton and Minot	8	434	6
Chambers	Green and Poplar	8	405	6
Brighton	Leverett and Lowell	8	355	6
Foundry	Dorchester ave. and Ontario	12	2,037	6
Ninth	D and Dorchester	10	1,392	6
B	Seventh and Broadway	8	1,228	6
Hartford	Sargent and Howard ave.	8	128	6

TAKEN UP AND ABANDONED.

48-inch	150	feet.
12 "	323	"
6 "	9,582	"
4 "	2,723	"

CHANGED.

29	1½	-inch	out	and	29	⅝	-inch	put	in
4	1	"	"	"	4	2	"	"	"
2	1	"	"	"	2	1½	"	"	"
1	1	"	"	"	1	1¼	"	"	"
7	¾	"	"	"	7	1	"	"	"
1	⅝	"	"	"	1	2	"	"	"
2	⅝	"	"	"	2	1½	"	"	"
8	⅝	"	"	"	8	1¼	"	"	"
24	⅝	"	"	"	24	1	"	"	"
9	⅝	"	"	"	9	¾	"	"	"
1	½	"	"	"	1	¾	"	"	"
8	½	"	"	"	8	⅝	"	"	"

Statement of Location, Size, and Number of Feet of Pipe laid in 1886.

NOTE. — B. indicates Boston; S.B., South Boston; E.B., East Boston; B.H., Boston Highlands; D., Dorchester; W.R., West Roxbury; Bri., Brighton.

In what Street.	Between what Streets.	District.	Size.	Length.
Fisher-hill reservoir lot,	From Fisher ave.	Bri.	36	169
Beacon	Over the R.R. bridge	"	"	368
	Total 36-inch			537
Brighton	Fisher ave and the R.R. bridge	Bri.	30	1,188
Fisher ave.	Brighton and Boylston	"	"	1,951
Dudley	Warren and Reservoir lot	"	"	860
Brookline reservoir lot,	Dudley and Boylston	"	"	979
Warren	Dudley and Cottage	"	"	1,508
Cottage	Warren and Boston line	"	"	1,891
Perkins	Brookline line and Prince	W.R.	"	341
Chestnut-hill reservoir lot	Beacon and the stable	Bri.	"	1,300
	Total 30-inch			10,018
Day	Heath and Creighton	B.H.	24	852
Heath	Day and Fisher ave.	"	"	270
Hayden	Heath and Fisher ave	"	"	497
Fisher ave.	Hayden and Parker	"	"	134
Parker-hill reservoir lot	Fisher ave. and the Reservoir	"	"	278
Perkins	Near Prince	W.R.	"	65
	Total 24-inch			2,096
Huntington ave.	Worthington and Wigglesworth	B.H.	16	186
Chestnut-Hill ave.	Beacon and Englewood ave.	Bri.	"	598
	Total 16-inch			784
Broad	Milk and India square	B.	12	703
Milk	India and Batterymarch	"	"	420
Dock sq. and Union	Devonshire and Hanover	"	"	792
Charlestown	Causeway and Stillman	"	"	1,160
Boylston	West Chester Park and Parker	"	"	400
West Chester Park	Westland and Newbury	"	"	816
	Carried forward			4,291

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	. . .	. . .	4,291
Brookline ave.	Beacon and R.R. bridge	B.	12	59
Foundry	Dorchester ave. and Fourth	S.B.	"	977
Boston	Ellery and Stewart	"	"	39
Breed	Ford and Leyden	E.B.	"	490
Ford	Saratoga and Breed	"	"	462
Lawrence ave.	Blue Hill ave. and Cedar	B.H.	"	563
Elm-Hill ave.	Howland and Wenonah	"	"	251
Prospect	Milton ave. and Norfolk	Dor.	"	607
Richfield	Puritan ave. and Olney	"	"	285
River	Blue Hill ave. and Hyde Park line	"	"	1,823
Blue-Hill ave.	McLellan ave. and Harvard	"	"	806
East Chester Park . .	Boston and Clapp	"	"	526
Erie ave.	New Seaver and Washington	"	"	351
Blue-Hill ave.	Norfolk and Fremont	"	"	599
Nelson	Norfolk and Evans	"	"	151
Southern ave.	Whitfield and Bernard	"	"	187
Washington	Bailey and Fuller	"	"	336
Codman	Dorchester ave. and Washington	"	"	404
Centre	Allston and Carlisle	"	"	103
Dudley ave.	Washington and Birch	W.R.	"	24
Hyde Park ave. . . .	Morton and Walkhill	"	"	584
" " " . . .	Ashland and Mount Hope	"	"	1,027
Gardner	Spring and Brookline line	"	"	584
Neponset ave.	Hyde Park ave and Folsom	"	"	210
Washington	Dudley ave. and La Grange	"	"	3,494
Corey	Garfield ave. and Weld	"	"	480
"	Park and Centre	"	"	404
Bellevue and the Field	Washington and Robin	"	"	1,640
Robin	Bellevue and Park	"	"	619
Park	Corey and Robin	"	"	1,937
Hyde Park ave. . . .	Neponset ave. and Stony Brook	"	"	497
Walter	South and Hewlitt	"	"	103
Beacon	Chestnut-Hill ave. and Roxbury ave.	Bri.	"	21
Western ave.	North Harvard and Cambridge line	"	"	210
	Total 12 inch	. . .	. . .	25,144

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
Foundry	Dorchester ave. and Fourth	S.B.	10	1,325
Ninth	D and Dorchester	"	"	1,392
Idaho	From River	Dor.	"	268
Spring	Clarence and Franklin ave.	W.R.	"	322
	Total 10-inch	...	...	3,307
Morgan	Columbus ave. and Stanhope	B.	8	235
Broad	State and Milk	"	"	478
Lowell	Brighton and Minot	"	"	434
Chambers	Green and Poplar	"	"	405
Brighton	Leverett and Lowell	"	"	355
Thorndike	Washington and Reed	"	"	240
Newman	Dorchester and Lowland	S.B.	"	831
Q	Fourth and Broadway	"	"	268
B	Seventh and Broadway	"	"	1,228
Curtis	Saratoga and Pope	E.B.	"	300
Leyden	From Breed	"	"	1,799
Dimock	Amory and Washington	B.H.	"	63
Mozart	Gilbert and Centre	"	"	1,019
Homestead	Nasby and Humboldt ave.	"	"	468
Quincy	Cedar and Magnolia	Dor.	"	131
Hartford	Sargent and Howard ave.	"	"	128
Alban	Ashmont and Welles ave.	"	"	48
Norfolk	Delhi and Cook's court	"	"	403
Puritan ave.	From Richfield	"	"	343
Milton	Adam and O.C. R.R.	"	"	163
Cushing ave.	Jerome and Upham ave.	"	"	289
Torrey	Washington and Gordon	"	"	49
Gleason	Harvard and Erie ave.	"	"	516
Franklin	Walnut and Taylor	"	"	96
Welles ave	Harley and Ocean	"	"	23
Sawyer ave	Cushing ave. and Pleasant	"	"	173
Boylston	Burr and C	W.R.	"	149
Symmes	Fairview and Walter	"	"	192
Cass	Spring and Summer	"	"	130
Summer	Cass and Autumn	"	"	616
	Carried forward	...	...	11,572

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	...	...	11,572
Robeson	Forest Hills and Sigourney	W.R.	8	80
Sycamore	Poplar and Ashland	"	"	484
Mt. Vernon	Pleasant and Garfield ave.	"	"	677
St. John	Centre and Rockview	"	"	100
Martin	Park and Wren	"	"	26
Centre	Bellevue and Vernon	"	"	410
Perkins	Near Prince	"	"	211
Proctor	Fairview and Walter	"	"	197
Walter	Hewlitt and Symes	"	"	511
Arlington	Parson and Market	Bri.	"	232
Mt. Vernon	Rockland and Church	"	"	252
Englewood ave.	Roxbury ave. and Beacon	"	"	161
	Total 8-inch	...	...	14,913
Batavia	Falmouth and Parker	B.	6	360
Hancock ave.	Beacon and Mt. Vernon	"	"	109
Isabella	Ferdinand and Columbus ave.	"	"	215
St. Botolph	West Chester Park and Cumberland	"	"	263
North Margin	Thacher and Lafayette ave.	"	"	237
Ivanhoe	West Canton and Trumbull	"	"	111
Cumberland	St. Botolph and Providence R.R.	"	"	273
Elm	Union and Washington	"	"	30
Fifth	G and H	S.B.	"	24
Fifth	H and I	"	"	153
Sixth	G and H	"	"	61
Athens	C and Second	"	"	1,360
Story	From G	"	"	73
O	First and the Water	"	"	435
Chaucer	Curtis and Moore	E.B.	"	585
Byron	Bennington and Milton	"	"	204
Cedar Park	From Highland Park	B.H.	"	58
Linden ave.	Linden Park and Siegel place	"	"	28
Savin	Blue-Hill ave. and Pupelo	"	"	142
Waumbeck	Warren and Wabon	"	"	55
Worthington place	From Tremont	"	"	134
	Carried forward	...	...	4,910

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	. . .	. . .	4,910
Montrose	Warren and Moreland	B.H.	6	103
Highland Park	Cedar and Fort ave.	"	"	26
Bumstead lane	Conant and Longwood ave.	"	"	257
Fellows	Webber and Hunneman	"	"	28
Ruthven	Nasby and Humboldt ave.	"	"	257
Tyso Park	From Dennis	"	"	317
Regent	Hurlburt and Ray	"	"	135
Rock	Rockland and Regent	"	"	66
Howland	Elm Hill ave. and Warren	"	"	28
Thornton	Juniper and Cedar	"	"	92
A (new street)	From Wyman	"	"	101
Minden	Posen and Bickford	"	"	72
Greenwich	Westminster and Warwick	"	"	273
Armstrong	Gilbert and Mozart	"	"	322
Winonah	Elm-Hill ave. and Waumbeck	"	"	431
Hestia Park	From Walnut ave.	"	"	217
Terrace	Heath and Alleghany	"	"	26
Elmwood place . . .	From Elmwood st.	"	"	225
Nasby	Ruthven and Homestead	"	"	286
Sussex place	From Hammond	"	"	256
Phillips	Tremont and Oriental court	"	"	75
Bromley	From Bromley Park	"	"	113
Linden	Dorchester ave. and Commercial	Dor.	"	323
Fairview	From Train	"	"	410
Burt ave.	Ashmont and Washington	"	"	100
Cottage place	From Cottage	"	"	430
Pilgrim "	" Richfield	"	"	158
A court	" Adams	"	"	321
Sidney	Harbor View and Crescent ave.	"	"	24
Hooper	Mellville ave. and Tremlett	"	"	359
Tremlett	Hooper and Washington	"	"	125
Beaumont	Carruth and Adam	"	"	106
Elm lawn	From Centre	"	"	269
Norton	" Bowdoin	"	"	382
	Carried forward	. . .	. . .	11,614

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	. . .	. . .	11,614
Longmeadow	Clifton and Batchelder	Dor.	6	72
Whitfield	Park and Norfolk	"	"	1,000
Delhi	From Norfolk	"	"	129
Payson	Hancock and Glendale	"	"	244
Fuller	Dorchester ave. and Washington	"	"	718
Corbett	Norfolk and Selden	"	"	332
Chickatawbut	Plain and Minot	"	"	144
Humphrey square . .	From Humphrey	"	"	141
Belden	Dudley and Boston	"	"	206
Sidney place	From Dudley	"	"	289
Sanborn ave.	" Harvard	"	"	422
Church place	" Washington	"	"	312
Leonard "	" Leonard	"	"	140
Leonard	Duncan and Clayton	"	"	34
Duncan	Leonard and Granger	"	"	5
Brooks	From Dorchester ave.	"	"	149
Gordon	Torrey and Dunbar ave.	"	"	366
Victoria	Dorchester ave. and Pleasant	"	"	425
Minot	Carruth and Frederika	"	"	179
Minot place	From Minot	"	"	35
Dorset	Boston and Dorchester ave.	"	"	111
Newhall	Ashmont and Newhall ave.	"	"	48
Bushnell	" " Fuller	"	"	378
Virginia	Bird and Davenport ave.	"	"	123
Granger	Clayton and Duncan	"	"	353
Abbott	Blue-Hill ave. and Harvard	"	"	103
Evans	Corbett and Forest Hill	"	"	178
Union ave.	Rossetter and Geneva ave.	"	"	132
Ocean	Wells ave. and Roslin	"	"	206
Spencer	Park and Talbot ave.	"	"	373
Brookside ave.	Chemical and Germania ave.	W.R.	"	217
Helena	Lamartine and Providence R.R.	"	"	48
Boylston place	From Boylston	"	"	212
Salem	Albano and Corinth	"	"	43
	Carried forward	. . .	. . .	19,481

Statement of Location, Size, etc. — *Continued.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	. . .	. . .	19,481
Nelson	Boylston and Spring Park	W.R.	6	279
Alden place	From Green	"	"	36
Meehan	Keyes and Williams	"	"	243
Conway	South and Fairview	"	"	121
Pine	Hancock and Sycamore	"	"	458
Brooks	Florence and Sycamore	"	"	611
Sycamore	Pine and Ashland	"	"	281
Rockview	Green and Hazel	"	"	211
Allen	Brown ave. and Rowe	"	"	147
Sigourney	Robeson and Walnut ave.	"	"	76
Hawthorne	Florence and Sycamore	"	"	186
Clifton	Kittridge and Albano	"	"	176
Atherton ave.	Washington and Albano	"	"	186
Corinth	Birch and Salem	"	"	136
A court	From Carolina ave.	"	"	179
Sheldon	Ashland and Prospect ave.	"	"	230
Prospect ave.	Hancock and Sheldon	"	"	111
Baker	Spring and Gardner	"	"	54
Water	Keyes and Williams	"	"	231
A (new)	From Spring	"	"	169
Garden	Brown ave. and Hancock	"	"	132
Peter	Falrview and Walter	"	"	327
Paul Gore	Chestnut ave. and Centre	"	"	219
Ballard	Centre and Custer	"	"	75
Wren	Robin and Martin	"	"	283
Lawndale terrace . . .	Lamartine and Providence R.R.	"	"	275
Franklin ave.	Spring and Hamilton	"	"	661
Carl	Corey and Kirk	"	"	392
Kirk	From Carl	"	"	360
Washington	Metropolitan ave. and Hemlock	"	"	202
Parley Vale ave. . . .	From Rockview	"	"	287
Herrick	Beacon and Hichborn	Bri.	"	230
Orchard	Guilford and Saunder	"	"	144
Saunder	Guilford and Orchard	"	"	189
	Carried forward	. . .	. . .	27,377

Statement of Location, Size, etc. — *Concluded.*

In what Street.	Between what Streets.	District.	Size.	Length.
	Brought forward	...	...	27,377
Waverley place	From Waverley	Bri.	6	241
Waverley	Waverly place and Western ave	"	"	410
Fairbank	Faneuil and Washington	"	"	229
Pearl	Franklin and Appian Way	"	"	34
Appian Way	Pearl and Vernon	"	"	325
Madison ave.	Washington and Union	"	"	108
Surrey	Parson and Market	"	"	264
A (new)	Surrey and Washington	"	"	103
Harvard ave.	Massachusetts ave. and Brookline line	"	"	30
Adam	From Everett	"	"	170
La Rose place	From Union	"	"	48
Linden	Massachusetts ave. and Brighton ave.	"	"	78
A court	From Tremont	"	"	139
Foster	Washington and Surrey	"	"	531
	Total 6-inch	...	...	30,087
Siegel place	From Lindall ave.	B.H.	4	135
Vine	From Vine	"	"	55
Heath ave.	From Heath place	"	"	17
Kensington Park	From Warren	"	"	104
	Total 4-inch	...	...	311

Statement of Location, Size and Number of Feet of Pipe Relaid and Abandoned in 1886.

In what Street.	Between what Streets.	District.	Size.	Length.	Size of Pipe as Relaid.
Beacon	Boston & Albany R.R. Bridge	B.	48	150	
	Total 48-inch	...	...	150	
Beacon	Brighton ave. and B. & A. R.R. Bridge	B.	12	323	
	Total 12-inch	...	...	323	
Broad	State and Milk	B.	6	478	8
"	State and India square	"	"	703	12
Milk	India and Batterymarch	"	"	420	12
Dock sq. and Union	Washington and Hanover	"	"	792	12
Charlestown	Causeway and Stillman	"	"	1,160	12
Lowell	Brighton and Minot	"	"	434	8
Chambers	Green and Poplar	"	"	405	8
Brighton	Leverett and Lowell	"	"	355	8
Elm	Across Union and North	"	"	50	
Foundry	Dorchester ave. and Ontario	S.B.	"	2,037	12
Ninth	D and Dorchester	"	"	1,392	10
B	Seventh and Broadway	"	"	1,228	8
Hartford	Sargent and Howard ave.	Dor.	"	128	8
	Total 6-inch	...	...	9,582	
Smith ave	From Kendall	B.	4	75	
Hancock ave	Beacon and Mt. Vernon	"	"	109	
North Margin	Thatcher and Lafayette ave.	"	"	237	
Ivanhoe	West Canton and Trumbull	"	"	111	
Newman	Dorchester and Lowland	S.B.	"	831	
Athens	Second and C	"	"	1,360	
	Total 4-inch	...	...	2,723	
	Raised.				
Beacon	Brookline ave. and St. Mary	B.	48	1,848	
"	Brookline ave. and Brighton ave.	"	16	112	
Brighton ave.	Beacon and St. Mary	"	12	300	
	Lowered.				
New Heath	Pynchon and B. & P. R.R. Crossing	B.H.	24	50	
Conant	Whitney and Huntington	"	6	104	
	Relaid.				
New Heath	Pynchon and B. & P. R.R. Crossing	B.H.	6	50	

Table showing the Length of Supply and Distributing Mains laid during the Year 1886, and the Length connected with the Sudbury and Cochituate Works, January 1, 1887.

	DIAMETER OF PIPE IN INCHES.														Totals.
	60	48	40	36	30	28	24	20	16	12	10	8	6	4	
EASTERN DIVISION.															
Length in use, Jan. 1, 1886	....	25,721	23,054	20,255	33,454	244	36,258	44,846	51,393	590,552	17,628	205,541	899,719	140,272	2,088,937
Stopcocks in same	....	1	7	12	15	....	32	30	84	856	8	372	2,190	606	4,213
Length laid or relaid during the year	....	....	....	537	10,018	....	2,096	....	784	25,144	3,307	14,913	30,087	311	87,197
Stopcocks in same	....	....	....	....	1	....	3	....	1	57	6	36	125	9	238
Length abandoned during the year	....	150	....	....	....	....	....	....	....	323	....	....	9,582	2,723	12,778
Stopcocks in same	....	....	....	....	....	....	....	....	....	1	....	....	24	8	33
Length in use, Jan. 1, 1887	....	25,571	23,054	20,792	43,472	244	38,354	44,846	52,177	615,373	20,935	220,454	920,224	137,860	2,163,356
Stopcocks in same	....	1	7	12	16	....	35	30	85	912	14	408	2,291	607	4,418
WESTERN DIVISION.															
Length in use, Jan. 1, 1887	266	16,051	1,435	1,166	2,140	....	....	....	20	2,043	....	....	360	....	23,481
Stopcocks in same	....	5	....	3	....	....	....	....	2	4	....	....	2	....	16
Total length connected with the works, Jan. 1, 1887	266	41,622	24,489	21,958	45,612	244	38,354	44,846	52,197	617,416	20,935	220,454	920,584	137,860	2,186,837 ft., equal to 414.16 miles.

Length of Hydrant, Blow-off, and Fire Reservoir Pipe, Jan. 1, 1887.

	16 inches.	12 inches.	9 inches.	8 inches.	6 inches.	4 inches.	Totals.
Total length in use, January 1, 1886	75	4,933	3,200	28	8,014	13,257	29,507
Length laid or relaid during the year	67	1,974	.....	.....	610	44	2,695
Length abandoned during the year	.....	.....	61	.....	51	358	470
Total length in use, January 1, 1887	142	6,907	3,139	28	8,573	12,943	31,732

Statement of Service-Pipes laid in 1886.

Diameter in Inches.	Boston.		South Boston.		East Boston.		Boston Highlands.		Dorchester.		West Roxbury		Brighton.		Totals.	
	Number of Pipe.	Length in Feet.	Number of Pipe.	Length in Feet.	Number of Pipe.	Length in Feet.	Number of Pipe.	Length in Feet.	Number of Pipe.	Length in Feet.	Number of Pipe.	Length in Feet.	Number of Pipe.	Length in Feet.	Number of Pipe.	Length in Feet.
1 3/4	1	13	....	....	....	....	....	....	....	....	....	....	....	....	1	13
1 1/2	1	25	....	....	....	....	....	....	....	....	....	....	1	43	2	68
1 1/4	2	89	....	....	....	....	2	74	....	....	....	....	....	....	4	163
1	18	668	2	59	....	....	8	210	8	336	5	240	3	42	44	1,555
3/4	21	621	3	327	2	59	21	463	12	289	1	40	1	17	61	1,816
5/8	212	7,401	152	4,179	93	2,555	280	7,545	379	10,538	233	6,314	129	3,719	1,478	42,252
Aggregate															1,590	45,867
Making total number up to January 1, 1887																53,400

Repairs of Pipes during the Year 1886.

WHERE.	Diameter of Pipes in Inches.																				
	48	40	36	30	24	20	16	12	10	9	8	6	4	3	2	1½	1¼	1	¾	⅝	½	Total.
Boston	1	2	4	1	.	2	1	12	.	.	3	33	26	2	4	31	1	7	8	269	3	410
South Boston	.	.	.	.	.	1	.	.	.	.	.	3	4	.	.	.	.	.	.	91	4	103
East Boston	.	.	.	.	.	4	.	.	1	.	1	1	.	.	.	.	.	1	1	55	14	78
Boston Highlands	.	.	2	.	2	1	.	9	.	1	.	8	2	3	.	3	.	2	.	124	1	155
Dorchester	.	.	.	.	.	.	.	6	.	.	.	9	2	.	.	.	.	1	.	71	1	90
West Roxbury	.	.	.	.	.	.	.	3	.	1	.	3	.	.	.	.	.	.	.	26	.	33
Brighton	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	5	.	6
Totals	1	2	6	1	2	8	1	30	1	2	5	57	34	2	7	31	1	11	9	641	23	875

Of the leaks that have occurred in pipes of 4 inches and upwards: joints, 62; settling of earth, 11; defective pipe, 22; defective packing, 38; defective stopcock, 11; by frost, 3; by blasting, 2; run onto by tug-boat, 1. Total . . . 150

Of 3-inch and in service-pipes: joints, 27; defective pipe, 73; defective packing, 25; defective faucet, 15; defective coupling, 9; settling of earth, 149; settling of sewer, 6; settling of wall, 2; faucet pulled out, 3; eat by soil, 2; struck by pick, 58; pipe not in use, 6; pipe twisted off 1; gnawed by rats, 7; by frost, 8; by blasting, 5. Total 396

Stoppage by rust, 216; by frost, 54; by fish, 31; by dirt, 23. Total 329

Total 875

Statement of Leaks and Stoppages, 1850–1886.

YEAR.	DIAMETER.		Total.
	Four inches and upwards.	Less than four inches.	
1850	32	72	104
1851	64	173	237
1852	82	241	323
1853	85	260	345
1854	74	280	354
1855	75	219	294
1856	75	232	307
1857	85	278	363
1858	77	324	401
1859	82	449	531
1860	134	458	592
1861	109	399	508
1862	117	373	490
1863	97	397	494
1864	95	594	489
1865	111	496	607
1866	139	536	675
1867	122	487	609
1868	82	449	531
1869	82	407	489
1870	157	707	926
1871	185	1,380	1,565
1872	188	1,459	1,647
1873	153	1,076	1,229
1874	434	2,120	2,554
1875	203	725	928
1876	214	734	948
1877	109	801	910
1878	213	1,024	1,237
1879	211	995	1,206
1880	135	929	1,064
1881	145	833	1,028
1882	170	1,248	1,248
1883	171	782	953
1884	253	1,127	1,380
1885	111	638	749
1886	150	725	875

HYDRANTS.

During the year 194 hydrants have been established and 69 abandoned.

	ESTABLISHED.					ABANDONED.					Total Difference.
	Boston Lowry.	Post.	Lowry.	Boston.	Total.	Boston. Lowry.	Post.	Lowry.	Boston.	Total.	
Boston	4	4	22	1	31	3	1	..	22	26	5
South Boston	...	16	17	..	33	2	1	..	19	22	11
East Boston	5	4	4	..	13	1	..	..	1	2	11
Boston Highlands	7	2	4	4	17	3	..	..	2	5	12
Dorchester	26	7	11	4	48	1	..	4	3	8	40
West Roxbury	26	5	8	5	44	2	..	..	3	5	39
Brighton	6	1	..	1	8	...	..	..	1	1	7
	74	39	66	15	194	12	2	4	51	69	125

Total Number up to January 1, 1887.

	Boston Lowry.	Boston Y.	Post.	Lowry.	Boston.	Total.
Boston	50	....	126	531	693	1,400
South Boston	17	1	51	161	307	537
East Boston	18	....	43	123	158	342
Boston Highlands	32	....	59	650	122	863
Dorchester	97	....	115	571	88	871
West Roxbury	95	....	216	104	60	475
Brighton	30	....	156	62	39	287
Deer Island	....	....	16	....	....	16
Brookline	....	....	....	5	3	8
Chelsea	....	....	....	....	7	7
	339	1	782	2,207	1,477	4,806

105 hydrants have been taken out and replaced by new or repaired ones, and 180 boxes have been taken out and replaced by new ones. The hydrants have had the usual attention paid them.

STOPCOCKS.

238 new stopcocks have been established this year. 174 boxes have been taken out and replaced by new ones. The stopcocks have had the proper attention paid them.

Respectfully submitted,

E. R. JONES,
Superintendent Eastern Division.

REPORT OF THE SUPERINTENDENT OF THE MYSTIC DEPARTMENT.

Mystic Department, Boston Water-Works,
Charlestown District, Jan. 1, 1887.

Col. Horace T. Rockwell, *Chairman Boston Water Board:*—

Sir, — The report of this department for the year ending December 31, 1886, is herewith submitted.

Mystic Lake.

Although the rainfall of the year was above the average, the available supply was so reduced, that we were obliged to pump from the lake into the conduit from Oct. 20 (the lake standing at that time, at 1.35) until Nov. 7 (the lake having risen to .40). The lake has continued to rise since that time, and all danger of pumping this season has passed. During the low water this season, we cleaned the shores of the lake from the railroad bridge to the old canal, rebuilt the northerly abutment to Bacon's bridge, and a piece of wall on the river banks, filled up the slough hole next to the railroad, and sowed it down to grass. I also took advantage of the low course of tides, and rebuilt the fishway, which was carried away by the freshet. During the summer a gang of men was kept in boats at work on Wedge Pond, cleaning the surface of the vegetable matter that grows in that pond. We averaged ten cart-loads per working-day for three months. I am satisfied that by commencing early in the season and following up the cleaning, the quality of the water, both in regard to taste and color, may be somewhat improved.

The cases of pollution have been watched very thoroughly, and the reports that have been filed each week show that we have succeeded in getting most of the filth strained through gravel instead of running direct into the streams that feed the lake.

All the buildings, bridges, and machinery are in good condition. I would recommend that a larger house be built at the lake.

Mystic–Valley Sewer.

The work on the sewer and at the pumping-station still continues to increase, and in a short time the plant will have to be enlarged if the present works are continued. There should be built this year a new engine and pump-house. There is needed at this place a spare pumping-engine, in case the present one breaks down. The engine has been repaired again this year, and begins to show the wear. I would recommend that a portable pump with boiler and engine be purchased.

Conduit.

The conduit remains in good condition. It was cleaned in May and September. At both times I found considerable moss and sponge which was thoroughly cleared off, and all the dirt was cleaned out of the gate-house. The pump asked for under the head of sewer, would be of great help in cleaning the conduit, as it is almost an impossibility to pump the dirt out with hand-pumps. The gate-house at the river-end of the conduit should be rebuilt and enlarged this year.

Reservoir.

The west division should be cleaned out this next season, and the stone-work pointed; the gutters have all been paved with asphalt the past season; it has improved the looks, and saved labor. The roads are still in poor condition.

Roads and Grounds.

All the roads are in the same condition as mentioned in last report, the recommendations of last year hold good for this. The buildings have all been painted. I would recommend that the gutters and sidewalks around the engine-house be paved with asphalt.

Pumping–Service.

No. 2 pump has been repaired this winter. The cracked cylinder on the low-pressure end gave out, and has been replaced by the one bought three years ago. The air-pumps on Nos. 1 and 2 have been repaired.

Our consumption has almost reached our pumping capacity. A modern high-duty pump would result in a saving of coal, and put us in better shape for the large consumption of the winter months. The roof of the engine-house requires repair, or to be replaced with a new one. The coal-bunker needs a

new covering, and should be enlarged so as to hold a year's supply of coal.

DISTRIBUTION–PIPES.

These have been extended by the addition of 192 ft. 4 in., and 252 ft. 6 in.; 3,705 ft. of cement-lined pipe has been replaced with cast-iron. 48 ft. of 16 in. iron pipe, was required to replace pipe of the same kind, owing to the freezing of the 16 in. across Malden bridge. The box covering this pipe has been rebuilt this year, and all danger of freezing has been prevented.

HYDRANTS AND GATES.

One additional Boston Lowry has been placed this year; 4 Post and 1 Flush have been replaced with Boston Lowrys; 11 Lowry hydrants opening against the pressure have been replaced with others opening with the pressure.

23 rotten hydrant-boxes have been renewed. I beg leave to call the attention of the Board to the abuse of the hydrants by other than the Fire Departments, it is almost an impossibility to keep hydrants in working order unless their use is properly regulated.

Three 4-in. and 1 6-in. gates have been added, 4 4-in., 8 6-in., 1 8-in., 1 10-in. have been replaced with new; 13 2-in. blow-offs on dead ends have been established; 72 rotten boxes were renewed.

SERVICE PIPES AND BOXES.

Fifty-one new services were laid, and 164 repaired, in which 1,089 feet of lead pipe were used, 42½ in. were replaced by larger size, 481 wooden service-boxes, were replaced by iron; 22 leaks were repaired; there were 62 stoppages by eels; 34 by rust; 3 by moss; and 1 by freezing.

New Services.

Size.	⅝-inch	¾-inch.	1-inch.	Total number.	Total feet.
Number	43	3	5	57	1,273

Summary of Services connected with the Works, January 1, 1887.

	Charlestown.	Somerville.	Chelsea.	Everett.	Total.
No. of Services .	5,694	4,626	4,712	1,078	16,110
Length in Feet .	152,560	155,891	126,683	23,936	459,070

459,070 feet, or 86 miles, 4,990 feet.

Breaks and Leaks on Distribution-Pipes.

Size of Pipes.	16''	8''	6''	4''	2''	Total.
Charlestown	1	1	4	6	5	17
Somerville	...	9	18	23	...	50
Chelsea	...	...	...	...	...	51
Everett	...	...	3	3	...	6
Totals	1	10	25	32	5	124

Extension of Distribution-Pipe.

Location.	Size of Pipe.			Total Feet.
	4-inch.	6-inch.	8-inch.	
Auburn avenue	120	.....	.....	120
Walker court	.....	252	.....	252
McCabe court	48	.....	.....	48
Somerville	1,025	4,621	612	6,258
Chelsea	221	896	.....	1,117
Everett	2,501	310	.....	2,811
Totals	3,915	6,079	612	10,606

Distribution-Pipes Relaid.

Location.	Original size.	4-inch.	6-inch.
	Inches.	Feet.	Feet.
Soley street	4	.....	660
Pleasant street	4	.....	516
Summer street	4	.....	384
Elm street	6	.....	1,440
Wallace court	2	156	.....
Frothingham avenue	2	156	.....
Cottage Row	2	168	.....
Eastern railroad	4	120	.....
Totals	.....	600	2,000

Summary of Gates Connected with the Works.

SIZE.	30-inch.	24-inch.	20-inch.	16-inch.	12-inch.	10-inch.	8-inch.	6-inch.	4-inch.	3-inch.	Total.
Charlestown	11	7	4	21	30	12	49	171	155	12	472
Somerville	.....	.....	.....	.....	6	5	8	193	211	.....	423
Chelsea	.....	.....	.....	1	.....	12	14	27	160	30	244
Everett	.....	.....	.....	.....	.....	3	3	39	48	4	97
Totals	11	7	4	22	36	32	74	430	574	46	1,236

Number of Hydrants Connected with the Works.

HYDRANTS.	Charlestown.	Somerville.	Chelsea.	Everett.	Totals.
Lowry	180	2	.....	1	183
Boston Lowry	15	.....	.....	.....	15
Flush	16	9	6	.....	31
Post	42	325	146	76	589
Totals	253	336	152	77	818

Summary of Pipes connected with the Works January 1, 1887.

LOCATION.	SIZE OF PIPE.											Total.
	36-inch.	30-inch.	24 inch.	20-inch.	16-inch.	12-inch.	10-inch.	8-inch.	6-inch.	4-inch.	3-inch.	2-inch.	
Charlestown	974	24,869	16,867	6,180	18,200	14,600	4,700	22,072	49,752	33,070	2,400	.....	193,684
Somerville	....	....	....	....	....	8,614	4,586	38,147	112,511	92,906	7,872	2,776	267,412
Chelsea	....	....	....	....	1,460	....	15,527	11,487	30,952	78,077	18,640	.....	156,137
Everett	....	....	....	....	....	....	7,128	2,481	40,378	35,076	914	215	86,192
Totals	974	24,869	16,867	6,180	19,660	23,214	31,914	74,187	233,593	239,123	29,826	2,991	703,425

703,425 feet, or 133.2 miles.

Connected with the works are the necessary tools, horses, and wagons to do the work, all of which are in good condition.

Yours respectfully,

J. HENRY BROWN,
Superintendent.

REPORT OF THE SUPERINTENDENT OF THE METER DIVISION.

OFFICE OF SUPERINTENDENT OF METER DIVISION,
221 FEDERAL ST., BOSTON, Jan. 1, 1887.

H. T. ROCKWELL, Esq., *Chairman Boston Water Board:* —

SIR, — The annual report of this department for the year ending Dec. 31, 1886, is herewith submitted.

The total number of meters in service to date, 3,891; Cochituate department, 3,419; Mystic department, 472.

During the year there have been 90 additional meters applied, and 749 discontinued, in the Cochituate department; and in the Mystic, 21 additional meters applied, and 146 discontinued.

286 new meters have been purchased, viz., 185 Crown; 74 Worthington; 23 Ball & Fitts, and 4 Frost.

325 meters have been sent to the factory for repairs. Of this number 123 were Crown; 188 Worthington; 9 Desper, and 5 Ball & Fitts.

During the year the following new meters have been tested by this department, and recorded at this office, and an official report of all has been made of the results of all meter-tests ordered by the Board: —

Name of Meter.	Size.	Kind.	Where Manufactured.
Hersey	$\frac{5}{8}$-in.	Rotary	Boston, Mass.
Fox, No. 1	$\frac{3}{4}$-in.	Single piston	" "
Little Giant	$\frac{3}{4}$-in.	Proportional	" "
Balance Valve	$\frac{5}{8}$-in.	Single piston	" "
Linscott, No. 1	$\frac{1}{2}$-in.	" "	Lewiston, Maine.
Fox, No. 2	$\frac{3}{4}$-in.	" "	Boston, Mass.
Freeman	$\frac{3}{4}$-in.	Double "	" "
Frost	$1\frac{1}{2}$, 1, $\frac{3}{4}$, $\frac{1}{2}$-in.	Single "	Manchester, England.
Linscott, No. 2	$\frac{3}{4}$-in.	" "	Lewiston, Maine.
Rowbotham	$\frac{3}{4}$-in.	Rotary	Philadelphia, Pa.
Hood	$\frac{3}{4}$-in.	Double piston	Boston, Mass.
Kent (English)	$\frac{3}{4}$-in.	Rotary	Philadelphia, Pa.
Undine (Improved)	$\frac{1}{2}$-in.	"	Hartford, Conn.
Thomson	1-in.	Diaphragm	New York.
Star	$\frac{3}{4}$-in.	Single piston	Boston, Mass.

Table showing Meters in Service, Jan. 1, 1887.

		6-in.	4-in.	3-in.	2-in.	1½-in.	1-in.	¾-in.	⅝-in.	½-in.	Total.	
Cochituate.	Worthington,	. . .	6	11	67	36	378	51	366	. . .	915	
	Worthington, B.W.W.	. . .	. . .	. . .	. . .	. . .	. . .	7	. . .	. . .	7	
	Crown . . .	1	9	18	23	33	152	96	1,063	. . .	1,395	
	Tremont . .	. . .	. . .	. . .	. . .	. . .	78	967	. . .	. . .	1,045	
	Desper . . .	. . .	. . .	. . .	. . .	. . .	2	1	16	. . .	19	
	Ball & Fitts .	. . .	. . .	. . .	. . .	. . .	6	7	11	. . .	24	
	All others . .	. . .	. . .	. . .	. . .	1	1	1	10	1	14	3,419
Mystic.	Worthington,	. . .	8	2	37	4	68	51	57	. . .	227	
	Crown . . .	2	6	5	5	2	19	36	115	. . .	190	
	Tremont . .	. . .	. . .	. . .	. . .	. . .	14	36	. . .	. . .	50	
	Ball & Fitts .	. . .	. . .	1	3	. . .	. . .	1	. . .	. . .	5	472
		3	329	37	135	76	718	1,254	1,638	1	. . .	3,891

12 1-inch and 76 ⅝-inch Worthington Meters have been condemned; worn out in service.

There have been 685 meters of various sizes taken out for test and examination.

59 new street boxes have been set; 177 removed, and 37 repaired.

93 meters of various sizes have been taken out frozen and burst, notwithstanding every precaution has been taken to protect them from frost. All outside meters have been packed with hay; also meters placed in cellars and other locations exposed to the cold have been boxed and hayed in a like manner.

Respectfully submitted,

GEO. S. FOLLANSBEE,

Superintendent.

REPORT OF THE SUPERINTENDENT OF THE INSPECTION AND WASTE DIVISION.

DIVISION OF INSPECTION AND WASTE,
CITY HALL, Jan. 1, 1887.

To HORACE T. ROCKWELL, Esq., *Chairman Boston Water Board:* —

SIR, — The following report of this division for the year, from January 1, 1886, to January 1, 1887, is respectfully submitted: —

The inspection force, previous to the 1st of January, 1886, consisted of 39 inspectors and five chief inspectors, making in all 44. The Water Board having decided that this force was too large, concluded to reduce it twenty-five per cent.; accordingly, the number was reduced to 34, viz., 31 inspectors and three chief inspectors. The force of the division was further reduced, by the resignation of the Office Clerk, Thornton Lewis, and Asst. Supt. M. J. Houghton; the place of the former was filled by the transference of inspector John J. McAuliffe to the clerkship. The vacancy caused by Mr. Houghton's resignation was not filled.

On January 18, the above force was formed into three inspection divisions, under the supervision of three chief inspectors; this is the present formation, except that one inspector was detailed for special work connected with the office.

Since the 18th of last February, in accordance with the order of the Water Board, monthly reports of the work of the division have been furnished to the Board.

Three inspectors were, on April 5, assigned for duty, in the Mystic Department, to inspect for assessing the water-rates of the present year, under the superintendence of the Water Registrar. They remained on that duty until Nov. 17.

Ten inspectors were, on May 1, detailed for duty under the Water Registrar to inspect the Cochituate Division for revenue; they finished their labors September 13, being engaged four and a half months, and then returned to their respective districts, under my supervision, to check waste, etc.

Inspector Joseph B. Neagle was for two months, viz.,

from May 12 to July 14, employed in Framingham, under the supervision of Engineer Desmond FitzGerald.

The detailing of the inspectors to the Cochituate and Mystic Divisions left but half the force during the summer months to perform the duties entailed by the Deacon meters, Church stopcock work, and general district supervision.

The division began April 1 to check the waste indicated by the Deacon meters and Church stopcocks, and the men were kept busy at this work until the 30th of November, when the work ended. It being impracticable to use the Deacon meters during freezing weather, the inspectors have to be solely relied upon to control the waste during the winter season.

As the inspection force was so greatly reduced during July, August, September, and October, the Board appointed two inspectors for special work during these months, viz.: to enforce the regulations relating to the use of hand-hose; the inspectors began July 26, and ended their labors Nov. 11, the result being that, from the vigilance exercised, fewer breaches of the ordinance were reported, and less fines inflicted in this respect than in previous years.

An additional special inspector was appointed for a month, viz., from Oct. 14 to Nov. 11, to enforce the hose rules in the Mystic Division.

The work, begun in November, 1885, of compelling water-takers to protect supply-pipes, liable to freeze in cold weather, was followed up during the year; 871 premises were notified to cover, or otherwise protect the pipes; in most instances the notices were complied with.

The following table of consumption shows that, notwithstanding that the population on the Sudbury river and Lake Cochituate supply has increased over 18,000 since the report was made, a saving of 20.28 per cent. was the result of last year's inspection; or, in other words, an average saving of 6,831,058 gallons for every day in the year as compared with the consumption for the year before inspection to check waste was begun: —

COCHITUATE DEPARTMENT.

MONTH.	BEFORE INSPECTION.	AFTER INSPECTION.	Average daily Saving.	Per cent. Saved.
	Average daily Consumption.	Average daily Consumption.		
	Gallons.	*Gallons.*	*Gallons.*	
	1882–1883.	1886.		
January, 1883	34,715,500	27,435,100	7,280,400	20.97
February, "	32,690,700	28,276,800	4,413,900	13.50
March, "	34,110,700	26,886,800	7,223,900	21.17
April, "	30,617,600	23,470,400	7,147,200	23.34
May, "	32,169,500	24,680,100	7,489,400	23.28
June, "	33,419,200	26,574,900	6,844,300	20.48
July, "	36,774,000	28,987,500	7,786,500	21.17
August, "	37,141,000	24,770,600	12,370,400	33.30
September, "	33,645,600	25,835,600	7,810,000	23.21
October, 1882	31,563,800	26,713,100	4,850,700	15.36
November, "	31,318,700	25,036,200	6,282,500	20.05
December, "	32,352,800	29,879,300	2,473,500	7.64
Averages for each month	33,376,591	26,545,533	6,831,058	20.28

The consumption in the Mystic Division has not been lessened by inspection. On the contrary, it has materially increased. All the waste that could be checked by the work of four or five inspectors was effected. It is not believed that any considerable waste exists in the Charlestown district. The increased consumption on this supply is not fully accounted for by increase of population, which has not increased probably more than 9,000 since the inspection began. The monthly reports of the City Engineer to the Water Board, however, accounts for the increased supply for September and December.

MYSTIC DEPARTMENT.

MONTH.	BEFORE INSPECTION. Average daily Consumption.	AFTER INSPECTION. Average daily Consumption.	Average daily Saving.	Per cent. Saved.	Increased Consumption.
	Gallons.	*Gallons.*	*Gallons.*		*Gallons.*
	1883.	1886.			
January	8,369,600	8,510,300	. . . . .	. . . . .	140,700
February . . .	7,714,700	9,275,700	. . . . .	. . . . .	1,561,000
March	7,737,300	7,780,000	. . . . .	. . . . .	42,700
April	6,171,100	6,856,600	. . . . .	. . . . .	685,500
May	6,319,100	6,412,400	. . . . .	. . . . .	93,300
June	6,912,500	6,941,100	. . . . .	. . . . .	28,600
July	7,307,600	7,437,500	. . . . .	. . . . .	129,900
August	7,261,500	7,166,800	94,700	1.30	. . . . .
September . .	5,846,300	7,585,200	. . . . .	. . . . .	1,738,900
	1882.				
October	6,011,300	6,552,000	. . . . .	. . . . .	540,700
November . . .	5,577,400	6,546,000	. . . . .	. . . . .	968,600
December . . .	6,877,600	8,043,500	. . . . .	. . . . .	1,165,900
Averages . .	6,842,166	7,259,175	. . . . .	. . . . .	591,316

The following table gives the work performed by each inspector in checking waste: —

INSPECTOR.	No. of Premises inspected for Waste.	DEFECTIVE FIXTURES.				WILFUL WASTE REPORTS.		Hose reports received.
		Reports received.	Notices to repair issued.	Reëxaminations made.	Fine notices issued for non repairs.	Reports received.	Fine notices issued.	
Daly, James F. . . .	4,753	343	396	670	2	. . . .	. . . .	. . . .
Hassett, John B. . .	4,869	374	348	390	6	. . . .	. . . .	. . . .
Dunn, John J. . . .	6,860	535	487	447	9	. . . .	. . . .	28
Smith, Lawrence . .	4,680	691	603	616	. . . .	. . . .	. . . .	25
Desmond, John F. .	4,903	261	246	208	2	2	2	
Rosnosky Raphael .	4,201	292	265	220	8	2	2	
Connolly, John A. .	2,971	84	75	53	1	. . . .	. . . .	
Quigley, John J. . .	3,084	139	310	154	. . . .	. . . .	. . . .	
Kilduff, William . .	5,642	586	538	475	19	5	5	4
McCarty, C. F. . . .	5,165	478	436	403	5	. . . .	. . . .	
Sweeney, C. F. . . .	2,204	127	79	23	. . . .	. . . .	. . . .	
Quigley, James L. . .	532	83	26	31	2	. . . .	. . . .	
Cassidy, M. F. J. . .	4,945	285	263	221	3	. . . .	. . . .	
Toland, Joseph H. .	4,196	102	89	59	2	. . . .	. . . .	
Berran, Joseph . . .	3,224	127	120	144	4	. . . .	. . . .	
Ross, George F. . .	5,031	481	431	385	10	4	4	1
Edmonds, Michael .	5,521	396	364	499	3	2	2	1
McNamara, John J. .	4,058	228	209	196	. . . .	. . . .	. . . .	
McCarthy, T., Jr. .	2,351	224	117	60	. . . .	. . . .	. . . .	
Finnigan, D. A. . .	6,002	635	583	454	4	1	1	3
Kane, James J. . . .	4,316	657	711	349	57	. . .	. . . .	2
Maguire, H. G. . . .	3,138	127	118	125	1	. . . .	. . . .	1
Murphy, John J. . .	4,633	610	571	530	46	10	10	4
Corbett, John J. . .	3,333	388	342	384	19	2	2	
Murray, Thomas . .	4,995	421	409	640	8	1	1	39
Roth, John H. . . .	1,292	850	739	224	69	2	2	
Leahan, John W. . .	3,219	301	279	1,525	6	. . . .	. . . .	4
Foye, John E. . . .	3,365	151	140	113	3	. . . .	. . . .	
Neagle, Joseph B. .	501	296	260	122	25	. . . .	. . . .	4
Wood, Walter B. . .	5,104	639	580	650	47	4	4	4
	119,094	10,952	10,134	10,370	361	35	35	120

During the year 480 fines were inflicted for non-repairs of water-fixtures, wilful waste, and violations of hose regulations. Of these, 77 were collected, and 403 abated for various causes.

During the same period the water has been cut off for non-payment of fines, etc., from 30 premises, and let on again to 29.

The amount of cash received for fines and turned over to the City Collector was $164.00, viz. : —

Cochituate Department	$132 00
Mystic "	22 00
Refunded to persons fined	10 00
	$164 00

Respectfully submitted,

D. B. CASHMAN,
Superintendent.

SUMMARY OF STATISTICS.

REPORT OF 1886.

In Accordance with the Recommendation of the New England Water-Works Association.

Boston Water-Works, Suffolk County, Massachusetts, supplies also the cities of Somerville and Chelsea, and the town of Everett.

Population by census of 1886: —	
Boston	390,393
Chelsea	25,709
Somerville	29,971
Everett	5,825
Total	451,898

Date of construction: —	
Cochituate works	1848
Mystic "	1864

By whom owned. — City of Boston.

Sources of supply. — Lake Cochituate, Sudbury River, and Mystic Lake.

Mode of supply. — Seventy per cent. from gravity works.
Thirty " " pumping "

Pumping.

	Cochituate.	Mystic.
Builder of pumping machinery,	H. R. Worthington, Boston Machine Co.	H. R. Worthington.
Description of coal used: —		
a Kind, —	Anthracite,	Bituminous.
c Size, —	Furnace,	Broken.
d Brand.		Elk Garden and Clearfield.
e Price per gross ton	$4.93 to 5.08	$3.96 and 4.09.
f Per cent. of Ash, —	14.9	8.8.

	Cochituate.	Mystic.
Coal consumed for year in lbs.,	1,981,200	5,869,500
Total pumpage for year in galls.,	1,065,221,000	2,700,676,300
Average dynamic head in feet,	111.65	148.82
Gallons pumped per lb. of coal,	537.7	460.1
Duty in foot lbs. per 100 lbs. of coal (no deductions).	50,065,200	57,108,200
Cost of pumping figured on pumping-station expenses, viz: —	$9,073 97	$21,639 15
Cost per million gallons raised to reservoir	$8 52	$8 014
Cost per million gallons raised one foot high	$0.0763	$0.0538

Consumption.

	Cochituate.	Mystic.
Estimated population	358,000	102,000
Estimated population supplied	350,000	100,000
Total consumption, gallons,	9,719,173,400	2,700,937,400
Passed through domestic meters	310,687,500	14,329,750
Passed through manufacturing meters	2,015,520,000	393,596,300
Average daily consumption, gallons	26,627,900	7,399,800
Gallons per day, each inhabitant	74.3	72.5
Gallons per day, each consumer	76.1	74.0
Gallons per day to each tap,	498	459

Distribution.

Mains.	Cast Iron.	Cast-Iron, Wrought-Iron, and Cement.
Kind of Pipe used: —		
Size	48-in. to 4-in.	30-in. to 3-in.
Extended, miles	14.1	2.0
Total now in use	414.2	133.2
Distribution pipes less than 4-in., length, miles	0	6.2
Hydrants added	125	37
Hydrants now in use	4,806	818
Stop-gates added	205	33
Stop-gates now in use	4,418	1,236

SERVICES.	Lead.	Lead and Wrought Iron.
Kind of Pipe used: —		
Size	$\frac{5}{8}$-in. to 2-in.	$\frac{1}{2}$-in. to 2.in.
Extended, feet . . .	45,867	18,536
Service taps added . .	1,590	182
Total now in use . .	53,400	16,110
Meters discontinued . .	659	125
Meters now in use . .	3,415	469
Meters and elevators in use,	348	0

FINANCIAL.

COCHITUATE WORKS. — MAINTENANCE.

Receipts.

DIVISION I.

From consumers: —		
Water-rates domestic		$609,062 66
" " manufacturing		466,703 02
Miscellaneous, sales, etc.		34,498 60
		$1,110,264 28
From public funds: —		
Hydrants	$92,380 00	
Fountains	000 00	
Street-sprinkling	4,453 26	
Public Buildings	33,465 75	130,299 01
Total receipts		$1,240,563 29

DIVISION II.

From fixed rates: —	
Domestic	$553,036 16
Manufacturing	252,321 68
	$805,357 84
From meter-rates: —	
Domestic	56,026 50
Manufacturing	344,680 35
Total receipts for water	$1,206,064 69

Expenditures.

Maintenance	$339,007 37
Refunded water-rates	702 69
Interest	680,993 51
Total maintenance	$1,020,703 57
Balance to sinking-fund	$219,859 72

Construction.

Extension of mains	$121,406 86
" " services	29,632 05
Setting sidewalk stopcocks	29,420 73
New high-service works	141,085 56
Additional supply	144,306 04
Total construction for year	$465,851 24
Total cost of construction to date	$18,973,616 03

FINANCIAL.

MYSTIC WORKS. — MAINTENANCE.

Receipts.

DIVISION I.

From consumers: —		
Water-rates domestic		$152,377 24
" " manufacturing		84,306 90
Miscellaneous		4,954 26
		$241,638 40
From public funds: —		
Hydrants	$7,301 92	
Street-watering	3,507 59	
Public buildings	2,115 97	
		$12,925 48
Total receipts		$254,563 88

DIVISION II.

From fixed rates: —		
Domestic		$149,765 77
Manufacturing		30,513 37
		180,279 14
From meter-rates: —		
Domestic		2,611 47
Manufacturing		66,719 01
Total receipts for water		$249.609 62

Expenditures.

Management and repairs	$134,439 43
Interest	45,323 75
Refunded water-rates	177 42
Water-rates refunded to Chelsea, Somerville, and Everett	42,669 63
Total maintenance	222,610 23
Balance to sinking-fund	31,953 65
	$254,563 88

Construction.

Extension of mains	$653 58
Total construction for year	$653 58
Total cost of construction to date	$1,657,458 97

APPENDIX A.

CORRESPONDENCE RELATING TO JAMAICA POND ACQUEDUCT CORPORATION.

[Copy.]

February 11, 1886.

Messrs. Horace T. Rockwell, William B. Smart, and Thomas F. Doherty, *Boston Water Board:* —

Gentlemen, — The Jamaica Pond Aqueduct Corporation hereby offers to sell to the City of Boston all its franchises and property for the sum of one hundred thousand dollars ($100,000) in cash, the city assuming and paying all taxes of the current year. Or, the Corporation will sell all its franchises and property to the city at such price as may be fixed by three disinterested men, one named by the city, one named by the Corporation, and the third named by the two so chosen.

This Corporation reserves the right to withdraw the above offers, unless one of them shall be accepted by the city within thirty (30) days from this date.

Truly yours,

(Signed), Jamaica Pond Aqueduct Corporation,
By MOSES WILLIAMS, *President.*

[Copy.]

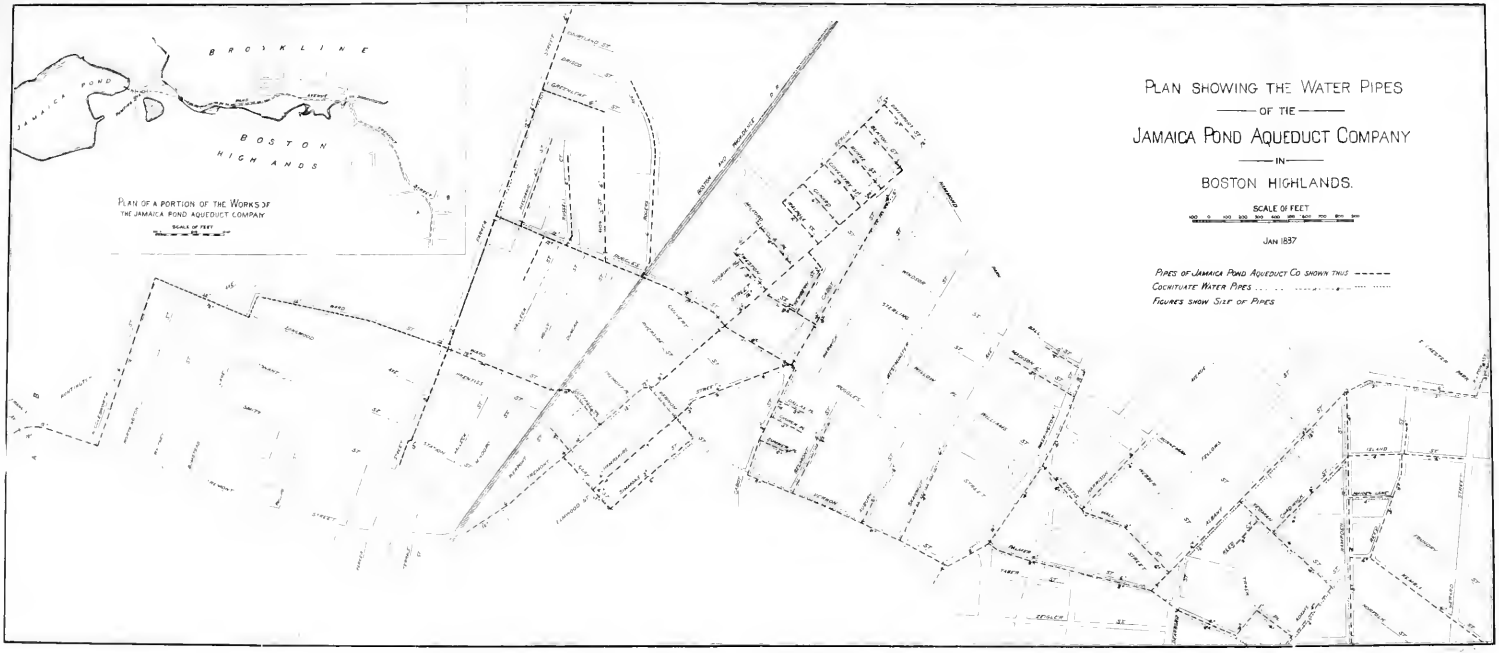
Office of City Engineer,
Boston, Feb. 20, 1886.

Col. H. T. Rockwell, *Chairman Boston Water Board:* —

Dear Sir, — The accompanying plan shows the location and size of the distribution pipes of the Jamaica Pond Aqueduct Co. in Roxbury, and also the sizes of the Cochituate pipes laid in the same streets.

The total length of the mains of the Jamaica Pond Co in Roxbury is 47,300 feet, or about 9 miles. Of this amount 33,000 feet are in streets which also contain the pipes of the Cochituate works, leaving 14,300 feet in streets where there are no Cochituate mains.

About 8,800 feet of the Jamaica Pond Co.'s mains could probably be connected with and made a portion of the Cochituate


BROOKLINE
JAMAICA POND
BOSTON HIGHLANDS
PLAN OF A PORTION OF THE WORKS OF THE JAMAICA POND AQUEDUCT COMPANY
SCALE OF FEET
PLAN SHOWING THE WATER PIPES
OF THE
JAMAICA POND AQUEDUCT COMPANY
IN
BOSTON HIGHLANDS.
SCALE OF FEET
JAN 1887
PIPES OF JAMAICA POND AQUEDUCT CO SHOWN THUS
COCHITUATE WATER PIPES
FIGURES SHOW SIZE OF PIPES

distribution; the remainder of the 14,300 feet being of smaller size or lighter weight than is used on the Cochituate works.

The cost of the changes necessary in the distribution system to connect all of the Jamaica Pond Co.'s water-takers with the Cochituate supply will be about $20,000.

Yours respectfully,

(Signed), WILLIAM JACKSON,

City Engineer and Engineer Boston Water Board.

[*Extract from Report of Water Board, City Doc. 173, 1883.*]

The sum paid by the corporation to the City of Boston in 1857, for its franchises, was . .	$32,000 00
The property was appraised by City Engineer Joseph P. Davis in December, 1874. [See City Doc. 108, 1874]	88,000 00
Land appraised by Joseph P. Davis. [See City Doc. 108, 1874]	15,700 00
Amount expended in construction since 1874, new pipes, additional land, etc.	69,943 64
Total cost to date	$205,643 64

	Receipts.		Running Expenses.
1880,	$12,063 50	About	$4,500
1881,	14,068 04	"	4,500
1882,	14,655 12	"	4,500
1883, [8 mo.]	13,516 23	" [8 mo.]	3,000

APPENDIX B.

CITY PHYSICIAN'S REPORT ON THE CAUSE OF THE PREVALENCE OF TYPHOID FEVER IN PHILADELPHIA.

Boston, January 1, 1887.

To The Boston Water Board: —

Gentlemen, — In compliance with your request to visit Philadelphia with you for the purpose of ascertaining, if possible, the cause of the prevalence of typhoid fever in that city, I have the following report to make: From information received from Mr. John L. Ogden, Chief Engineer of the Water Department, it has been found that the greatest number of deaths from typhoid fever occurred in those localities where the water of the Delaware river was used only to a limited extent. In this section, however, there are a great number of wells, defective sewers, and privy-vaults. An examination of the register of the Water Department shows that in the infected district there are 4,578 houses which have no connection with the city pipes. Supposing that there are five persons in each house, a very small allowance, there must be at least 22,890 individuals who depend upon wells for their drinking-water. This taken in connection with the fact that the hygienic surroundings are of the poorest, and also with the fact that the privy-vaults are in close proximity to these wells, would seem to be a sufficient explanation of the cause of the epidemic.

Dr. Henry Leffmann, Port Physician of Philadelphia, in reply to a letter says, "I am inclined to blame Delaware water, but I also lean strongly to the Pettenkofer view that the subsoil water and surroundings have much to do with the continued existence of this disease. I have satisfied myself that a considerable proportion of the cases are either not typhoid, or are contracted out of the city, nevertheless, the fact remains that a fatal fever having most of the symptoms of true typhoid is almost endemic in the north-east section of this city."

In a pamphlet by this physician, entitled, "Typhoid Fever in Philadelphia," the following statements are found. . . . .

"An examination of the statistics goes to show that the district north of Girard avenue, and between Ninth street and Frankford avenue, presents always the most unfavorable showing. It was the district that suffered most from cholera in 1866; from small-pox in 1872–73, and 1881–82; its death-rate from all diseases, and from especially zymotic diseases, is higher than in most other sections. If we look carefully into the conditions which prevail in

this section, I think we can discern, if not all causes of the excess in mortality, at least many of them. The section is comparatively newly occupied territory. The population is largely composed of foreign-born persons, many of them imported especially for the manufacturing operations carried on in the district, and of about the age at which the fever appears to be most frequent. The condition of the drainage, both natural and artificial, is of the most objectionable description. The ravines and meadows constituting the original water-courses have been filled up for street extension, without proper care, and as a large portion of the material which is used for filling up, is house and mill refuse, many of the rows of houses have been built over garbage. Dr. Wm. R. Cruice, who has had a large experience with the diseases of this section, has given me a description of the situation. The question of water-supply must, of course, enter largely into our thoughts in investigating this subject. There is a large and, I think, increasing number of sanitarians and physicians who regard the disease as strictly a germ disease, that is incapable of originating except from a previous case. To these the hypothesis of water-carriage is entirely acceptable, and they would regard the above-mentioned soil, climatic and social conditions, as merely predisposing. The Kensington district has, for a long while, been supplied with Delaware water, and by general consent, the disproportionate amount of diarrhœal disease has been ascribed to this fact.

"Yet we cannot overlook the fact that the district of Kensington proper, now substantially included within the Eighteenth ward, does not show a specially high death-rate from typhoid. The high death-rate is seen particularly in the district which has been laid out and built up since the war. I am inclined to think that if water-carriage is an active factor, in this case, in the distribution of zymotic disease, it takes place in a manner different from that usually supposed. The consumption of water in mills is an important item, and the high taxes imposed by the city for water privileges has led to a very extensive sinking of shallow wells for general mill supply. I have examined a number of samples so obtained, from different parts of the city, and, as might be expected, the water generally shows evidence of contamination. It is, however, frequently quite clear and cool, and the mineral matters and gases contained in it give it a pleasant taste, for which reason the operatives prefer it to the river-water; and I know that such well-water is often used even after it has been expressly pronounced unsafe. There is reason to believe that several slight local epidemics may be traced to such a cause. Recently such an outbreak occurred at the Glen Echo carpet mills, in the lower end of Germantown, and all the deaths occurring in the Twenty-second ward during November and December, 1885, were of persons employed in those mills. Dr. J. Howard Taylor, Medical Inspector of the Board of Health of this city, and myself, investigated the epidemic, and could find no other source but the drinking of well-water.

"Dr. E Frank Ganett writes, in reference to a death occurring

in Germantown, earlier in the year, that although no other person had the disease in the same house, there were several in the same square, and all of them used well-water. I think considerable importance ought to be attached to the nativity of those affected. The foreign-born population of the district that suffers most from the disease is not only large in proportion, but in many cases of the quite recent arrivals. They are the operative class, and are, indeed, the actual specimens of the 'pauper labor' of which so much is said in tariff discussion. This class is not certainly in the best physical condition, and being new to the district, are all the more likely to succumb. I find, by examining the figures for six months of 1884, that the proportion of foreign-born persons dying of typhoid fever is much larger than the proportion dying of all diseases. The statistics, in my opinion, entirely negative the hypothesis that Schuylkill water is an important factor of the disease. This view has, indeed, never been tenable. No analysis of the water has justified the wholesale condemnation of it which has been so frequent of late years. The distribution of the mortality from zymotic disease has been several times examined, with a view to show such a connection, but it has failed. The report of the Water Department for 1883 presents an examination of this question, and it fails entirely to make out a case against the Fairmount supply. It would be impossible to discuss a topic like this without saying something about sewer-gas, or rather, as it ought to be called, sewer-air. When I was a medical student, the sewer theory of infectious diseases was a favorite one. My preceptor, the late Dr. Rand, laid much stress upon this agent as a cause of disease. We have recovered from this extreme state of alarm, and some of our leading sanitarians now teach that it can only act as an exciting cause where it carries specific germs. As in the case of the Schuylkill water, the topographical study of typhoid fever in Philadelphia does not bear out the theory of sewer-air as a cause. The districts in which the residences are most extensively connected with sewers, through the medium, not only of water-closets, but of those much more insidious routes, the wash-stand and kitchen-sink, are just the districts in which the fever is least prevalent."

In the discussion of this paper at a meeting of the Philadelphia County Medical Society, November 24, 1885, Dr. F. P. Henry says: . . . . . "Several observers, among them Virchow, have shown that typhoid fever is more prevalent during dry seasons, which is in strict accord with the celebrated observations of Pettenkofer and Buhl, that, in Munich, the number of cases of typhoid fever bears a relation to the height of the water springs, being most prevalent when these are low. These Munich observers do not believe in the propagation of the typhoid poison by means of the drinking water, and explain the undoubted coincidence between the prevalence of typhoid and a low level of the subsoil water by the theory that when the earth is uncovered by the recession of the water the air gains access to germs previously submerged, and stimulates them to unusual activity. The poison, they say, gains access to the body through the medium of the atmospheric air.

"Dr. Henry B. Baker, Secretary of the Michigan State Board of Health, has recently verified the statements of Pettenkofer and Buhl, that the rise and fall of the typhoid fever curve are in inverse ratio to the rise and fall of the subsoil water, with the following notable exception; namely, that in winter, when the ground is deeply frozen, a low level of subsoil water does not correspond with an increased prevalence of typhoid."

Dr. Cruice remarks: "I wish simply to say that the cases which I have treated during the last summer were not among immigrants. The majority of them were old residents in the neighborhood, and many of them were workers in the mills. A large number of the residents along Germantown road use pump-water. I have no doubt that much of the trouble has come from that source. These cases occurred in newly-built districts. A number of the houses were built on ground made from the dumping of ashes and other *débris*. I observed the same condition in 1872, when I treated a number of cases of small-pox."

Dr. Richard A. Cleemann says: "I am glad to see that the observations of Dr. Leffmann confirm those which I made in the epidemic of 1876. It was at that time very unpopular to say that typhoid fever was not caused by contamination of sewer-gas, or from the water-supply. Careful examination then showed that neither the sewers nor the water-supply could be held responsible for the large majority of deaths from typhoid fever in Philadelphia.

"In the absence of any apparent cause, I was disposed to refer it to emanations from the number of open cesspools, which were often in close proximity to the houses, and to the constant pollution of the soil from them, which became very obnoxious, from the subsequent turning up of this soil. . . . I do not deny that the poison of typhoid fever can be communicated through water. On the contrary, I think that it is often carried in that way, but that in Philadelphia polluted water is not a prominent cause. In all the epidemics from poisoned drinking water, the number attacked, among those who drank the water, has been very large, a very much larger proportion of the inhabitants than have been attacked in Philadelphia by typhoid fever."

Dr. Edward T. Bruen says: . . . "The modern consensus of opinion points to the fact that disease does not arise without the presence of the poison. It does not arise *de novo*. In regard to the influence of cesspools, I had an opportunity of observing a number of cases of the disease originating near Rosemond Station. Most of these cases occurred from a centre near which a large number of the houses had recently been built, some twenty or twenty-five, on an acre of ground. These were occupied by the working-class. The privy-wells and water-wells had been sunk near by."

Dr. James C. Wilson remarks: . . . "The second question of Dr. Leffmann relates to the relative frequency of typhoid fever in this community, among newly-arrived individuals. Such individuals are particularly subject to this disease. This was seen three or four years ago, in the Paris epidemics. It was observed that those who came in from the country were especially liable to

contract the disease, and to have it in a grave form. This is also the case in our own city. I think that this is not only true of localities, but also of houses. I have in mind at present two houses in which I have seen enteric fever develop in a number of individuals, at intervals in the course of a series of years. In one of these houses, of three cases, two were individuals who came from a distance, and in a few weeks or months developed the disease. These cases occurred at intervals of eighteen months or two years. Local defects of plumbing are usually largely concerned in establishing *foci* of infection."

Dr. S. S. Cohen says: "In regard to the causation of enteric fever by the water-supply, I recall two cases that I saw last year in one family living in the Nineteenth ward. These persons had for three weeks used water from the well of a factory where the father worked, having been frightened by the newspaper accounts of the pollution of river-water. Two sons were taken with mild typhoid, and a daughter with non-febrile diarrhœa. I could find no source of infection other than the drinking water. In regard to this district, I may say that we see, at the Jefferson Medical College clinic, a good many cases of 'walking typhoid' in residents of the north-eastern part of the city. We also see some few cases in residents of the 'Neck' district. It is from these same localities that we get the greatest number of our malarial cases."

Dr. William M. Welch, says: . . . "In seeking for the cause of typhoid fever, we must look to the soil and drinking water. Whenever soil, especially polluted soil, is upturned to any considerable extent, there is pretty sure to be typhoid fever."

Dr. Charles Claxton, remarks: "In my experience, as resident of the Episcopal Hospital, and in private practice in the Nineteenth ward, I have seen many cases of typhoid fever. The almost invariable source of infection I have found to be defective sewerage, usually from exposed privy-wells. Such is the condition in some of these residences, that during a heavy rain the contents of these wells are flooded into the yards, and thence into the cellars, where they would remain for long periods. I have now under my care four members of one family, whose sickness is undoubtedly due to this wretched state of affairs."

In regard to the subject of the communication of typhoid fever through the medium of drinking water, particularly of that supplied by wells, it may be of interest to cite two examples. In Ziemssen's Cyclopædia of the Practice of Medicine, — a work of the highest authority — Vol. 1, page 60, is found the following: "Epidemic in the 'Soherenfabrik' in Basle, 1867. In a collection of houses situated at some distance from the city, of which the inhabitants numbered about one hundred and fifty, mostly girls, of thirteen to seventeen years old, there were no cases of typhoid fever during the severe epidemic at Basle, 1865 and 1866. In the year 1867, when the epidemic had subsided in the city, a single case appeared in January, a second case in February, and in May a large number, so that within twenty-two days thirty-six persons were attacked with typhoid fever, and many others with febrile and afebrile abdominal catarrh. It was shown that the well from which

the drinking water was drawn, was fed from a canal into which emptied the privy. Eighteen days after the use of the water was forbidden there were no more new cases. A little later, three more cases occurred in persons who had probably disobeyed and drunken of the water. After the well was completely closed there were no more cases.

"Epidemic in the barracks at Zürich, 1865. In these barracks thirty-three recruits of the infantry school were attacked within seven days. After the dismissal of the recruits twenty-two more were seized. All the cases occurred in the infantry school; the members of the artillery school and the police, stationed in the same barracks, were exempt from the disease. The cause was found in a well, situated in the exercise-ground, only used by the infantry, from which they frequently drank. Close to this well was a receptacle into which were thrown refuse matters from the city. Chemical analysis showed the water to contain impurities from this receptacle. When the well was closed, and the refuse removed, no more typhoid appeared in the barracks."

In Boston, previous to the introduction of Cochituate water, typhoid fever was very prevalent. It is true that during the past ten years this disease seems to have increased in frequency. This increase is apparent rather than real, however, as an examination of the following table, compiled by Dr. Erwin F. Smith, of Ann Arbor, Michigan, will show: —

Table of Deaths from Typhoid Fever, in Boston, from 1846 to 1884.

Year.	Population (estimated or enumerated).	Typhoid Fever.		
		Total Deaths.	Deaths per 10,000 living.	
1846	116,865	133	11.4	
1847	122,346	300	24.5	17.4
1848	127,827	288	22.5	
1849	133,308	149	11.2	
1850	138,788	104	7.5	
1851	142,693	170	11.9	
1852	146,598	110	7.5	8.2
1853	150,503	111	7.4	
1854	154,408	102	6.6	
1855	158,313	90	5.7	
1856	162,218	76	4.7	
1857	166,123	86	5.2	5.0
1858	170,028	75	4.4	
1859	173,934	85	4.9	
1860	177,840	110	6.2	
1861	180,735	96	5.3	5.7

Table of Deaths, etc. — Concluded.

Year.	Population (estimated or enumerated).	Typhoid Fever.		
		Total Deaths.	Deaths per 10,000 living.	
1862	183,630	74	4.0	
1863	186,526	130	6.9	5.7
1864	189,422	117	6.2	
1865	192,318	137	7.1	
1866	195,214	101	5.2	
1867	198,110	91	4.6	5.6
1868	230,911	120	5.1	
1869	236,000	148	6.2	
1870	250,526	168	6.7	
1871	256,000	176	6.8	
1872	254,400	229	9.0	7.6
1873	260,000	243	9.3	
1874	313,745	202	6.4	
1875	360,122	227	6.3	
1876	352,842	145	4.1	
1877	363,000	156	4.2	4.2
1878	363,000	120	3.3	
1879	363,000	119	3.2	
1880	362,839	154	4.1	
1881	397,628	207	5.2	
1882	410,376	212	5.1	4.9
1883	427,940	198	4.6	
1884	427,940	216	5.4	

It should be stated that forty years ago physicians, as a rule, did not recognize the difference between typhus and typhoid fever, and for this reason the tables cannot be considered absolutely correct; but the sources of error are so slight as not to materially influence the result. The following extract from a letter from a physician, whose professional experience extended over a period of fifty-five years, may be of interest. This extract was published in the report of the State Board of Health, January, 1871, page 127: "I have noticed since the time when Cochituate water was introduced that typhoid fever has been less frequent, in proportion to the population, and generally mitigated in its character. . . . . At the early part of my professional life, fever of a severe type was quite common, much more so than a few years later, and the cases were of a more serious character

than at any subsequent period. . . . . Cases of what is now recognized as 'typhus' were not then uncommon; they are now comparatively rare Mild cases of 'typhoid' fever, such as have of late been most common, do not readily arise to the remembrance of the practitioner of that early time. . . . . From the period referred to, down to the time of the introduction of Cochituate water, fevers had still been lessening in frequency and severity. It has been noticed that since the introduction of pure water the diminution of typhoid fever, both in frequency and virulence, has been still more marked."

From a study of the investigations of Dr. Henry Leffmann; from the opinions of many eminent physicians in Philadelphia; from the information gained in regard to the number of wells and privy-vaults in the infected district; from the fact that in this section of the city there are 4,578 houses, which are not connected with the city pipes, it may be considered as proved: —

1. That the prevalence of typhoid fever in Philadelphia is largely due to the contamination of the well-water by privy-vaults.
2. That the defective sewers, by polluting this well-water, are also very important factors in the causation of this disease.
3. That there is very little proof that the water of the Delaware river has caused the prevalence of this disease.

As a corollary to the foregoing propositions, it may be stated, that in Boston, when we take into account the limited number of wells, the improved system of sewers, the small number of privy-vaults, and the rigid laws in regard to the pollution of the water-supply, there is no danger of an epidemic of typhoid fever.

Respectfully submitted,

JOHN H. McCOLLOM,

City Physician.

CIVIL ORGANIZATION OF THE WATER-WORKS, FROM THEIR COMMENCEMENT TO JANUARY 1, 1887.

WATER COMMISSIONERS.

NATHAN HALE, JAMES F. BALDWIN, THOMAS B. CURTIS. From May 4, 1846, to January 4, 1850.

ENGINEERS FOR CONSTRUCTION.

JOHN B. JERVIS, of New York, Consulting Engineer. From May, 1846, to November, 1848.

E. S. CHESBROUGH, Chief Engineer of the Western Division. From May, 1846, to January 4, 1850.‡

WILLIAM S. WHITWELL, Chief Engineer of the Eastern Division. From May, 1846, to January 4, 1850.

CITY ENGINEERS HAVING CHARGE OF THE WORKS.

E. S. CHESBROUGH, Engineer. From November 18, 1850, to October 1, 1855.‡

GEORGE H. BAILEY, Assistant Engineer. From January 27, 1851, to July 19, 1852.

H. S. MCKEAN, Assistant Engineer. From July 19, 1852, to October 1, 1855.

JAMES SLADE, Engineer. From October 1, 1855, to April 1, 1863.

N. HENRY CRAFTS, Assistant Engineer. From October 1, 1855, to April 1, 1863.

N. HENRY CRAFTS, City Engineer. From April 1, 1863, to November 25, 1872.

THOMAS W. DAVIS, Assistant Engineer. From April 1, 1863, to December 8, 1866.

HENRY M. WIGHTMAN, Resident Engineer at C. H. Reservoir. From February 14, 1866, to November, 1870.‡

A. FTELEY, Resident Engineer on construction of Sudbury-river works. From May 10, 1873, to April 7, 1880.

JOSEPH P. DAVIS, City Engineer. From Nov. 25, 1872, to March 20, 1880.

HENRY M. WIGHTMAN, City Engineer. From April 5, 1880, to April 3, 1885.‡

WILLIAM JACKSON, City Engineer. From April 21, 1885, to present time.

After January 4, 1850, Messrs. E. S. CHESBROUGH, W. S. WHITWELL, and J. AVERY RICHARDS were elected a Water Board, subject to the direction of a Joint Standing Committee of the City Council, by an ordinance passed December 31, 1849, which was limited to keep in force one year; and in 1851 the Cochituate Water Board was established.

COCHITUATE WATER BOARD.

Presidents of the Board.

THOMAS WETMORE, elected in 1851, and resigned April 7, 1856‡ . . . . . Five years.

JOHN H. WILKINS, elected in 1856, and resigned June 5, 1860‡ . . . . . Four years.

EBENEZER JOHNSON, elected in 1860, term expired April 3, 1865‡ . . . . . Five years.
OTIS NORCROSS, elected in 1865, and resigned January 15, 1867‡ . . . . . One year and nine months.
JOHN H. THORNDIKE, elected in 1867, term expired April 6, 1868‡ . . . . . One year and three months.
NATHANIEL J. BRADLEE, elected April, 6, 1868, and resigned January 4, 1871 . . . Two years and nine months.
CHARLES H. ALLEN, elected January 4, 1871, to May 4, 1873 . . . . . Two years and four months.
JOHN A. HAVEN, elected May 4, 1873, to Dec. 17, 1874‡ . . . . . One year and seven months.
THOMAS GOGIN, elected Dec. 17, 1874, and resigned May 31, 1875 . . . . . Six months.
L. MILES STANDISH, elected August 5, 1875, to July 31, 1876 . . . . . One year.

Members of the Board.

THOMAS WETMORE, 1851, 52, 53, 54, and 55‡ . . Five years.
JOHN H. WILKINS, 1851, 52, 53, *56, 57, 58, and 59‡ . Eight years.
HENRY B. ROGERS, 1851, 52, 53, *54, and 55 . . . Five years.
JONATHAN PRESTON, 1851, 52, 53, and 56 . . . Four years.
JAMES W. SEAVER, 1851‡ . . . . . One year.
SAMUEL A. ELIOT, 1851‡.
JOHN T. HEARD, 1851‡ . . . . . One year.
ADAM W. THAXTER, Jr., 1852, 53, 54, and 55‡ . . Four years.
SAMPSON REED, 1852 and 1853‡ . . . . . Two years.
EZRA LINCOLN, 1852‡ . . . . . One year.
THOMAS SPRAGUE, 1853, 54, and 55‡ . . . . Three years.
SAMUEL HATCH, 1854, 55, 56, 57, 58, and 61 . . . Six years.
CHARLES STODDARD, 1854, 55, 56, and 57‡ . . . Four years.
WILLIAM WASHBURN, 1854 and 55 . . . . . Two years.
TISDALE DRAKE, 1856, 57, 58, and 59‡ . . . . Four years.
THOMAS P. RICH, 1856, 57, and 58‡ . . . . Three years.
JOHN T. DINGLEY, 1856 and 59‡ . . . . . Two years.
JOSEPH SMITH, 1856‡ . . . . . Two months.
EBENEZER JOHNSON, 1857, 58, 59, 60, 61, 62, 63, and 64.‡ Eight years.
SAMUEL HALL, 1857, 58, 59, 60, and 61‡ . . . . Five years.
GEORGE P. FRENCH, 1859, 60, 61, 62, and 63‡. . . Five years.
EBENEZER ATKINS, 1859‡ . . . . . One year.
GEORGE DENNIE, 1860, 61, 62, 63, 64, and 65 . . . Six years.
CLEMENT WILLIS, 1860 . . . . . One year.
G. E. PIERCE, 1860‡ . . . . . One year.
JABEZ FREDERICK, 1861, 62, and 63‡ . . . . Three years.
GEORGE HINMAN, 1862 and 63 . . . . . Two years.
JOHN F. PRAY, 1862 . . . . . One year.
J. C. J. BROWN, 1862 . . . . . One year.
JONAS FITCH, 1864, 65, and 66‡ . . . . . Three years.
OTIS NORCROSS, *1865 and 66‡ . . . . . Two years.
JOHN H. THORNDIKE, 1864, 65, 66, and 67‡ . . . Four years.
BENJAMIN F. STEVENS, 1866, 67, and 68 . . . . Three years.
WILLIAM S. HILLS, 1867 . . . . . One year.
CHARLES R. TRAIN, 1868‡ . . . . . One year.
JOSEPH M. WIGHTMAN, 1868 and 69‡ . . . . Two years.
BENJAMIN JAMES, *1858, 68, and 69 . . . . Three years.
FRANCIS A. OSBORN, 1869 . . . . . One year.
WALTER E. HAWES, 1870‡ . . . . . One year.
JOHN O. POOR, 1870 . . . . . One year.
HOLLIS R. GRAY, 1870 . . . . . One year.

NATHANIEL J. BRADLEE, 1863, 64, 65, 66, 67, 68, 69, 70, and 71	Nine years.
GEORGE LEWIS, 1868, 69, 70, and 71	Four years.
SIDNEY SQUIRES, 1871‡	One year.
CHARLES H. HERSEY, 1872	One year.
CHARLES H. ALLEN, 1869, 70, 71, and 72	Four years.
ALEXANDER WADSWORTH, *1864, 65, 66, 67, 68, 69, and 72	Seven years.
CHARLES R. MCLEAN, 1867, 73, and 74‡	Three years.
EDWARD P. WILBUR, 1873 and 74	Two years.
JOHN A. HAVEN, 1870, 71, 72, 73, and 74‡	Five years.
THOMAS GOGIN, 1873, 74, and 75*	Three years.
AMOS L. NOYES, 1871, 72, and 75	Three years.
WILLIAM G. THACHER, 1873, 74, and 75‡	Three years.
CHARLES J. PRESCOTT, 1875	One year.
EDWARD A. WHITE, 1872, 73, 74, 75, and 76†	Five years.
LEONARD R. CUTTER, 1871, 72, 73, 74, 75, and 76†	Six years.
L. MILES STANDISH, 1860, 61, 63, 64, 65, 66, 67, 74, 75, and 76†	Ten years.
CHARLES E. POWERS, *1875 and 1876†	Two years.
SOLOMON B. STEBBINS, 1876†	One year.
NAHUM M. MORRISON, 1876†	One year.
AUGUSTUS PARKER, 1876†	One year.

*Mr. John H. Wilkins resigned Nov. 15, 1855, and Charles Stoddard was elected to fill the vacancy. Mr. Henry B. Rogers resigned Oct. 22, 1865. Mr. Wilkins was re-elected Feb., 1856, and chosen President of the Board, which office he held until his resignation, June 5, 1860, when Mr. Ebenezer Johnson was elected President; and July 2 Mr. L. Miles Standish was elected to fill the vacancy occasioned by the resignation of Mr. Wilkins. Otis Norcross resigned Jan. 15, 1867, having been elected Mayor of the City. Benjamin James served one year, in 1858, and was reëlected in 1868. Alexander Wadsworth served six years, 1864–69, and was reëlected in 1872. Thomas Gogin resigned May 31, 1875. Charles E. Powers was elected July 15, to fill the vacancy occasioned by the resignation of Mr. Gogin.

† Served until the organization of the Boston Water Board.

‡ Deceased.

BOSTON WATER BOARD, *Organized July 31, 1876.*

TIMOTHY T. SAWYER, from July 31, 1876, to May 5, 1879; and from May 1, 1882, to May 4, 1883.
LEONARD R. CUTTER, from July 31, 1876, to May 4, 1883.
ALBERT STANWOOD, from July 31, 1876, to May 7, 1883.
FRANCIS THOMPSON, from May 5, 1879, to May 1, 1882.‡
WILLIAM A. SIMMONS, from May 7, 1883, to Aug. 18, 1885.
GEORGE M. HOBBS, from May 4, 1883, to May 4, 1885.
JOHN G. BLAKE, from May 4, 1883, to Aug. 18, 1885.
WILLIAM B. SMART, from May 4, 1885, to present time.
HORACE T. ROCKWELL, from Aug. 25, 1885, to present time.
THOMAS F. DOHERTY, from Aug. 26, 1885, to present time.

ORGANIZATION OF THE BOARD FOR YEAR 1886.

Chairman.

HORACE T. ROCKWELL.

Clerk.

WALTER E. SWAN.

City Engineer and Engineer of the Board.

WILLIAM JACKSON.

Water Registrar.

WILLIAM F. DAVIS.

Deputy Collector and Clerk, Mystic Department.

JOSEPH H. CALDWELL.

Superintendent of the Eastern Division of Cochituate Department.

EZEKIEL R. JONES.

Superintendent of the Western Division of Cochituate Department.

DESMOND FITZGERALD.

Superintendent of Mystic Department.

J. HENRY BROWN.

Superintendent of Meter Division.

GEORGE S. FOLLANSBEE.

Superintendent of Inspection and Waste Division.

D. B. CASHMAN.

‡ Deceased.

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